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Future@Labs.Prosperity Game™

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Prosperity Games™

Abstract

Prosperity Games™ are an outgrowth and adaptation of move/countermove and seminar War Games. Prosperity Games™ are simulations that explore complex issues in a variety of areas including economics, politics, sociology, environment, education, and research. These issues can be examined from a variety of perspectives ranging from a global, macroeconomic and geopolitical viewpoint down to the details of customer/supplier/market interactions in specific industries. All Prosperity Games™ are unique in that both the game format and the player contributions vary from game to game.

This report documents the Future@Labs.Prosperity Game™ conducted under the sponsorship of the Industry Advisory Boards of the national labs, the national labs, Lockheed Martin Corporation, and the University of California. Players were drawn from all stakeholders involved including government, industry, labs, and academia.

The primary objectives of this game were to:

- Explore ways to optimize the role of the multidisciplinary labs in serving national missions and needs.
- Explore ways to increase collaboration and partnerships among government, laboratories, universities, and industry.
- Create a network of partnership champions to promote findings and policy options.

The deliberations and recommendations of these players provided valuable insights as to the views of this diverse group of decision makers concerning the future of the labs.

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Acknowledgments

A complex event such as this requires the efforts and encouragement of a large number of people. Funding was provided by four national labs: Lawrence Livermore, Los Alamos, Sandia, and Oak Ridge. The labs' Industry Advisory Boards, Lockheed Martin Corporation, and the University of California co-sponsored the event.

Deborah Wince-Smith and an executive committee comprised of members of the national labs provided outstanding guidance, solicitation of players, and help in the develop of the game objectives and its final design. Outstanding contributions to the success of this game were made by Alan Bennett, Charryl Berger, Gordon Longerbeam, Pete Lyons, Sarah Nitzel, Gladys Shaw, Gary Sycalik, Olen Thompson, Dick Traeger, and Deborah Wince-Smith. We would also like to acknowledge Warren Siemens for his support and encouragement throughout the entire process of designing and conducting the Prosperity Game.

Staff from Sandia, Los Alamos, Lawrence Livermore, Oak Ridge, and their contractors provided outstanding facilitation for the game and analyses of the results.

Seventy-eight players and twenty-nine staff committed themselves to the success of this game, and their efforts are greatly appreciated. Special thanks to those players from industry, government, labs and academia who took time out from their very busy schedules to contribute to this simulation.

Executive Summary

The future of the DOE national laboratories is a major topic of discussion in Washington. The primary mission of the original national laboratories was the creation and maintenance of the nuclear deterrence portion of the national defense system. Over the years, additional missions have been created in the areas of civilian nuclear power, energy R&D, and environmental research and waste management. With the reduction of the threat of nuclear war and the reduction of federal spending on science and technology, the role of the national laboratories is being reevaluated. This Prosperity GameTM was designed to investigate that role for today and the future.

This was the fourteenth Prosperity Game™ that has been conducted. The game was sponsored by the Industry Advisory Boards of four national laboratories: Lawrence Livermore, Los Alamos, Oak Ridge, and Sandia, in collaboration with the Lockheed Martin Corporation and the University of California. This Prosperity Game™ was designed to accomplish the following objectives:

- Explore ways to optimize the role of the multidisciplinary labs in serving national missions and needs.
- Explore ways to increase collaboration and partnerships among government, laboratories, universities, and industry.
- Create a network of partnership champions to promote findings and policy options.

The game incorporated twelve basic teams. The US government was represented by Congress, the Department of Energy, and Other Federal Agencies. US industry was simulated by four industry teams, each with a pair of technology focus areas: information technology and advanced manufacturing; energy and environment; life sciences and advanced materials; and national security and criminal justice. Other interests and stakeholders were modeled by teams representing foreign countries, universities, national security labs, civilian science and technology labs, and a Control team to help run the game and represent all other entities.

The game exposed many elements of the rapidly changing labs' environment, both positive and negative. Predominantly driven by a desire for high returns on investment, industry often saw the labs either as a supermarket for off-the-shelf technologies that could be rapidly commercialized, or as not especially relevant to their needs. Universities have often seen the labs as sources of funds, or markets for their primary products - graduate students. Many teams initially felt that the labs were not major players in the US R&D environment. The concept of win-win partnerships was new to many, and the game afforded an opportunity to pursue these possibilities.

Partnering in the initial phase of the game was modest, with a median of only one additional partner per Toolkit investment. In the later phases of the game, the median number of additional partners increased to three; concomitantly, the creativity and the success probability of investments increased with the number of partners.

In the initial Toolkit phase of the game, the primary technology investments were in energy and environment. Over the entire game, information technology and life sciences also garnered large investments. On average, the investments of the players were very similar to actual technology area investments in the US, although the split among the investing teams was different.

Major policy changes in the game focused on three areas: R&D tax credits, laboratory system governance/structure, and lab budgets. There was a broad consensus favoring a variety of different kinds of tax credits. The game also introduced issues related to labs consolidation, privatization and closure, creation of a system of labs, formation ofFraunhofer-like institutes, and authorization to conduct certain types of foreign R&D. The Congress team also passed laws that dealt with trade initiatives, preserving critical industries, creating a Department of Economic Security, a Corporate Teaming Act, a Small Business Research Program, and reform of the FDA.

In a mock “R&D National Summit Meeting,” the players discussed the relevancy of the labs in R&D, ways to improve the creation, funding, and performance of technology in the US, including metrics, and ways to develop clean, inexpensive sources of energy, especially for transportation.

The teams experienced a varying amount of success. Most of the industry teams focused on maximizing their returns on investment (ROI). One team had difficulty accepting the reality of moves of other teams, and the estimates of cost and ROI. Nevertheless, all the industry teams vigorously pursued their objectives, often with great success.

The Congress team produced many new laws and policies, recognized the importance of metrics and returns on federal R&D investment, and the need for maintaining defense readiness. Although judged to be among the best performing teams, they were often perceived by others as slow and obstructionist. The Congress team felt that this was primarily due to poor communications to the other teams.

The DOE team assessed its play as very realistic in the sense of not being able to find out-of-the-box solutions. The Other Federal Agencies team was very successful and cooperated highly synergistically within their team (in contrast to the real world where they rarely meet except to fight over appropriations). They felt a need to develop a shared set of priorities among the many agencies, and use the labs’ resources efficiently. However, the team was disturbed by the initial lack of interest in proposals concerning national security.

The two labs teams’ performance increased significantly over the game. The National Security Labs team garnered 13% of all the game’s funds in pursuit of their own initiatives (despite owning only 2.9% of total game funds within their team). They also raised 23% of all the game money spent on other teams’ agreements for their own initiatives. The Civilian S&T Labs were also successful in attracting partners, with 7% of all game funds and 13% of funds spent on other team’s agreements devoted to their own programs.

The Universities team started slowly. However, their performance increased dramatically as they pursued a grand challenge to cure genetically predisposed diseases. The universities would like to increase their collaborations with the labs, especially focusing on joint appointments and employment. The Foreign team adopted two roles of developed and developing nations. They pursued important global goals (food, water, etc.) with a high degree of success. They also managed to avoid an impending Asian war through negotiations with Congress.

Some teams used the game to develop real working relationships with other teams and with their own teams. For example, the Civilian S&T labs players felt that the networking opportunity afforded by the game was a great benefit; they agreed to meet and confer on a monthly basis as a result of the game.

Several teams felt that the labs needed to do more in marketing and public relations to deal with the relevancy issue.

Based on a subjective set of six metrics, including the overall quality of life in the US, the players’ actions had a positive effect compared to baseline predictions.

Perhaps the most stunning success of the Prosperity Game™ to date has been the commitment of many players to participate in follow-on activities. The “R&D National Summit Meeting” in the game will have real-life counterparts; the Council on Competitiveness is planning some regional R&D summits, and a national summit meeting next year.

The game planners have conducted meetings to develop committed champions and a set of tasks and areas to be pursued. Eight follow-on, self-directed teams have been formed: DOD/Lab Interactions; National System of DOE Labs; Public Affairs; Marketing; University/Lab Partnerships; Government Interactions; International Programs; and Industry/Lab Partnerships. All teams have a pair of lab and private sector people helping to guide their activities.

Although a large shift in perspectives is not expected over the course of a three-day game, the players' views did change. Comparing entrance and exit polls, the following changes were observed:

- R&D is more important to the future quality of life than first envisioned.
- Partnerships among labs, industry, and universities is more important to the nation than first thought.
- The players are more familiar with the capabilities and facilities of the labs as a result of the game.
- The idea of expanding the missions of the national labs beyond their current role decreased to just above neutral by the end of the game.

Some players experienced difficulties over the approximations required in the game, or over the nature of the investments made by other players. Overall, however, the majority of players greatly enjoyed and learned from the experience:

- "Very well executed game. Strengths: effort to incentivize teams, give real-time feedback, alter the strategic environment. Weakness: very broad focus, lack of expertise on teams."
- "An important activity for bringing different cultures, different priorities to the forefront and open to discussion."
- Stimulating, enjoyable, intense, draining, well organized and planned."
- "Participation in these Prosperity Games was a valuable and rewarding experience. As someone who's real-life responsibility is partnering and collaboration, it was most beneficial to get others' perspectives and attitudes toward partnering."
- "Good game experience and I learned a lot. I believe the games have many indirect benefits in terms of relationships and opportunities to be followed and built on."
- "An enriching experience.... The planning and game design were excellent. The pace of learning was quick, but there was adequate time for reflection."
- "Game was an excellent exercise. A major factor in its success was the caliber of the participants and their enthusiastic participation."
- "Amazed at how much is similar to reality in this accelerated game."
- "The initial hectic pace and paucity of information on how the game worked were very true to normal industry operation."
- "Very useful game - stimulated thinking, created the potential for future initiatives and built a network of interested parties who can make things happen."
- "Developed a better understanding of need to partner and to market lab capabilities."

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Introduction

Future of the DOE National Laboratories

The future of the DOE national laboratories is a major topic of discussion in Washington, as are federal and industrial investments in research and development. The end of the Cold War created expectations of a "peace dividend." The new Republican majority in the 104th Congress committed itself to reduce the deficit, cut or eliminate many federal programs, and require that government expenditures be justified by their benefits to the nation. Some have forecast that federal support for research will be reduced by 30% over the next five years.

The primary mission of the original national laboratories was the creation and maintenance of the nuclear deterrence portion of the national defense system. Over the years, additional missions have been created in the areas of civilian nuclear power, energy R&D, and environmental research and waste management. A huge national investment has been made in laboratories facilities, infrastructure and the creation of a pool of enormously talented scientists and engineers.

With the diminution of the threat of global war and the reduction of federal spending on science and technology, the US "technology delivery system" is being reevaluated in terms of national needs, missions, funding resources (federal, industry, foreign) and R&D performers (national laboratories, universities, industry, foreign countries).

A year ago, the Galvin Commission[1] concluded that "energy" in its broadest definition should serve as the mission for the labs. "The laboratories' research role is a part of an essential, fundamental cornerstone for continuing leadership by the United States…. We note that many of the least exploited investigative paths involve the need for extraordinarily sophisticated multidisciplinary teams using sophisticated instruments and tools. It is that role for which the national laboratories are uniquely qualified. It is the case for – the justification of – the existence of the DOE laboratories…. The Task Force does believe that the national laboratories serve a distinctive role in conducting long-term, often high-risk R&D, frequently through the utilization of capital-intensive facilities which are beyond the financial reach of industry and academia, and generally through the application of multidisciplinary teams of scientists and engineers."

Although the Task Force supported innovative applications of the labs' technical competencies (e.g., high performance computation, advanced materials, systems engineering) to new problem areas, they suggested that these applications would not be likely to evolve into new missions per se.

More recently, a National Academies of Sciences and Engineering committee chaired by Frank Press[2] recommended closing some national labs and directing more research funds away from the labs and into universities.

In any period of resource contraction, there is a tendency for in-fighting and competition for the shrinking pie. However, it is also possible that the interests of all can be better met by partnerships, synergistic approaches, and the reduction of redundancy. Metrics on the return on private and public investments are essential.

Science and technology may play a large role in the '96 elections. On February 15, Vice President Gore said "… we have a choice of two paths. One path retreats from understanding, flinches in the face of challenges

1 Department of Energy, Task Force on Alternative Futures for the Department of Energy National Laboratories, February 1995, http://www.bnl.gov/TID/GALVIN/gv1.html.

[2] Allocating Federal Funds for Science and Technology, Committee on Criteria for Federal Support of Research and Development, National Academy Press, Washington, DC 1995, http://www.nap.edu/nap/online/fedfunds

and disdains learning…. But there's another path… on which government continues funding basic science and applied technology. It's a path that keeps the virtuous circle of progress and prosperity alive and functioning…. It's a path that applies what we've learned from science to the rest of our lives."

This Prosperity Game™

The Industry Advisory Boards of the national laboratories, in collaboration with the laboratories, Lockheed Martin Corporation, and the University of California, have sponsored this Prosperity Game™ to explore the roles of industry, government, universities, and laboratories in the rapidly changing research environment.

This simulation was designed to provide participants with an understanding of some of the threats and opportunities associated with the current US technology delivery system. Prosperity Games™ are an invaluable learning experience that can create exciting alternative futures as well as explore the current real world.

Objectives of this Game

This Prosperity Game™ was designed to accomplish the following specific and general objectives:

SPECIFIC:

- Explore ways to optimize the role of the multidisciplinary labs in serving national missions and needs.
- Explore ways to increase collaboration and partnerships among government, laboratories, universities, and industry.
- Create a network of partnership champions to promote findings and policy options.

GENERAL:

- Develop partnerships, teamwork, and a spirit of cooperation among industry, government, laboratory and university stakeholders.
- Increase awareness of the needs, desires and motivations of the different stakeholders.
- Bring conflict into the open and manage it productively.
- Explore long-term strategies and policies.
- Provide input for possible future legislation.
- Stimulate thinking.
- Provide a major learning experience.

Freedom rings where opinions clash.
- Adlai E. Stevenson

The specific objectives were to be met through the players and teams acting separately and in concert with others to explore the future and their own challenges. General objectives were met through the simulation process itself.

Game Concept and Description

Overview

TEAMS:
The game incorporated the twelve basic teams shown in Figure 1. The US government was simulated by three teams representing the US Congress, the Department of Energy, and Other Federal Agencies (e.g., DOD, DOC, DOT, DOA, HHS, NASA, EPA, NSF, FAA, etc.). US industry was simulated by four industry teams representing four different technology focus areas: information technology and advanced manufacturing; energy and environment; life sciences and advanced materials; and national security and criminal justice. National security, broadly defined, (see Appendix L: Glossary) was also of major interest to other teams. Other technology areas like sensors, instrumentation, micrœlectronics, photonics, robotics, etc., could be pursued by any team with an interest in those technologies. Foreign governments and businesses were represented on the Foreign Countries team. The research establishments were represented by a University team and by two lab teams, the DOE National Security (weapons) Labs and the DOE Civilian Science and Technology (energy, environment, etc.) Labs; of course, R&D could also be performed by industry. The Control Team conducted the game, resolved all disputes, and played all other roles and functions required in the game including news media, publications, polling, computing, adjudicating, and if needed, finance, labor, voters, special interest groups, etc.

PLAYERS:
Every Prosperity Game is unique because the outcomes depend on the players. Players were selected to faithfully represent their real-life roles. Their creativity and commitment to the simulation determined the success of the game. A list of the players and their team assignments is given in Appendix B.

GAME DESCRIPTION AND SCENARIO:
The primary game objective was to explore the roles of the labs in serving national missions and needs.

Figure 1. This Prosperity Game™ explored relationships among many entities.

This exploration required highly skilled players with a strong knowledge of the existing R&D system, and the confidence to make decisions, observe their consequences, and alter their decisions accordingly.

The play simulated the time period from May 1996 to the end of 2005, a compression of ten years into two days. This time compression of 2000:1 (1 game minute ≈ 1.5 days) means that many aspects and issues were treated very approximately.

The central theme of the game, as in real life, was the relationship among all the stakeholders in the competition for scarce public and private resources. The public is concerned about the percentage of national income that is taken by the government, and the allocation of that money to competing government needs, especially between current consumption and future investment. Industry is also concerned about the allocation of resources to ongoing company operations versus future investments. All stakeholders would like to have metrics to evaluate the success or failure of previous decisions and to help guide future decisions.

Players were assigned to one of the stakeholder teams. They were expected to play their assigned roles faithfully by protecting the interests of their constituents. Challenges were defined for each team. The players were instructed to review and modify those challenges and develop others. They were then to develop strategies to accomplish their objectives and meet their challenges over the course of the game.

The game had few rules. The primary "move" in the game was a written agreement or contract, which represents a step along the path leading to the accomplishment of the team's objectives. The agreements were to be robust, penetrating, and carefully crafted. These agreements are negotiated among two or more teams and must represent an exchange of value for value. The quality of the agreements is more important than their quantity.

No agreement was deemed official until signed by all consenting parties and the Control team. If the agreements involved uncertain future outcomes (such as the result of a new research investment), success or failure was determined probabilistically by the Control team. All agreements were accompanied by the amount of money being invested by those involved in the agreement. Teams were allocated money during the game to use to accomplish their objectives. Allocations approximately modeled the real world. An important test for any "move" (action, agreement, contract, partnership) was its reality. The form used for all agreements is given in Appendix A.

Players had two ways in which they could alter the future. One was the conventional approach discussed above that involves negotiations, contracts, and investments among the stakeholders in a realistic process that evolves within the game. These were the game "moves" as recorded on the agreement forms. The second way to change the future was through Toolkit options (see p. 5). These were pertinent (but undeveloped) technology and policy choices that were provided to stimulate creativity in the game. The players were allowed to invest in the given options or create their own. Special allocations of Toolkit money or "credits" were assigned; these credits could only be used for Toolkit investments.

Playing the Game

The Prosperity Game included six sessions or distinct time periods. The simulation explored empathic and learning experiences, collaborative and competitive interactions, experimentation, decision making, and innovation. A final debriefing allowed the teams to share their experiences with the entire group.

All teams were provided with a list of near-term and long-term challenges that could be modified or supplemented as desired (see Appendix A). This information, coupled with the experience and expertise of the players, launched them into the real-world simulation of the game. The game was "won" by successfully meeting the prescribed challenges and accomplishing the long-term objectives of the teams and individual players. Circumventing the game was not considered winning. Players were to seek to accomplish their goals following the most realistic alternatives available within the constraints of the simulation.

This experiential process developed the relationships and provided the inputs and innovative thinking that will be used for follow-on activities and planning.

Teams were to play their roles, and negotiate and interact with each other. They were also to develop research plans; get sponsors and funding; invest in new technologies, implement new policies, get products patented, licensed and manufactured for use in subsequent years. In the context of the game, all specified long-duration events (such as building new facilities for research or manufacturing) were assumed to have already been accomplished in the event of a successful outcome.

Session 1: 1996-1997: In this session, the players were to focus on strategic planning and organizing their teams to best deal with the coming events. They were also to:

- decide on ground rules for making decisions
- determine individual roles and assign responsibilities
- determine processes for accountability and correcting errors
- know the deadlines and deliverables

- resolve outstanding questions about the game
- review the detailed descriptions of their team and other teams
- discuss the challenges provided in the game handbook
- add others challenges of their choosing; prioritize
- review their current state and where they would like to be in 10 - 20 years
- begin to consider their technology and policy Toolkit investments
- negotiate with other teams

Session 2: 1997: Teams were to focus on the list of Toolkit technologies and policies, and determine how to invest their limited resources. Toolkit investments were required to be submitted by the end of Session 2. No money was disbursed in Sessions 1 or 2.

Teams were responsible only for their own Toolkit investments. However, they were encouraged to discuss pooling their Toolkit resources with other teams to increase the likelihood of success.

After the Toolkit option investment period ended, teams were required to use realistic (agreement) processes for developing and marketing new technologies. This could include development of Toolkit options that previously failed, or their own technology and policy ideas.

Session 3: 1998-1999: Successful Toolkit options were announced and implemented into the game. Money was distributed to all the teams according to a very approximate estimate of actual R&D spending and the relative influence of the stakeholder groups.

In Session 3, teams were to continue their deliberations, strategy modifications, interactions and negotiations with other teams, generation of new ideas and technologies, etc. Thus, Session 3 created the basic kernel (pattern for game play) for Sessions 4 and 5.

Figure 2 illustrates some (but not all) of the possible interactions that could occur during Sessions 3 - 5. The background of the figure shows the R&D areas that the labs are currently pursuing.

Session 4: 2000-2001: Session 3 activities continued. Policy changes were incorporated into the game. Champions of particular technologies and policies were to pursue the agreements necessary to bring their ideas to fruition.

At the end of Session 4, the President convened a Summit Meeting to discuss the future of R&D in the US. Each team sent a representative to the summit, which was conducted as a plenary session.

Session 5: 2002-2003: Session 4 activities continued. Active play ceased at the end of this session.

Session 6: 2004-2005: This session was for digesting the results of the game, and the progress each team had made in meeting its challenges and accomplishing its objectives. Follow-on activities were to be proposed and discussed.

Outbriefings: Each team was to prepare a final briefing and select a spokesperson. Topics were to cover: team issues and objectives; interfaces with others (collaborative, competitive, other); what was learned; and conclusions. Each team was allowed 5 minutes for its presentation.

Wrap up and final polling: Players answered questions and filled out evaluation forms.

Over the course of the game, six metrics were tracked and updated by the Control team. These metrics were an attempt to estimate the impact of the players' moves on the future. The metrics are discussed in a later section (see p. 39).

Unexpected events centered around economic and military instability in China were inserted into the game. These events had only a minor impact on the final game state due to team actions.

Toolkit Options

The Toolkit is a significant part of every Prosperity Game™. It gives teams the opportunity early in the game to implement technologies and policies without

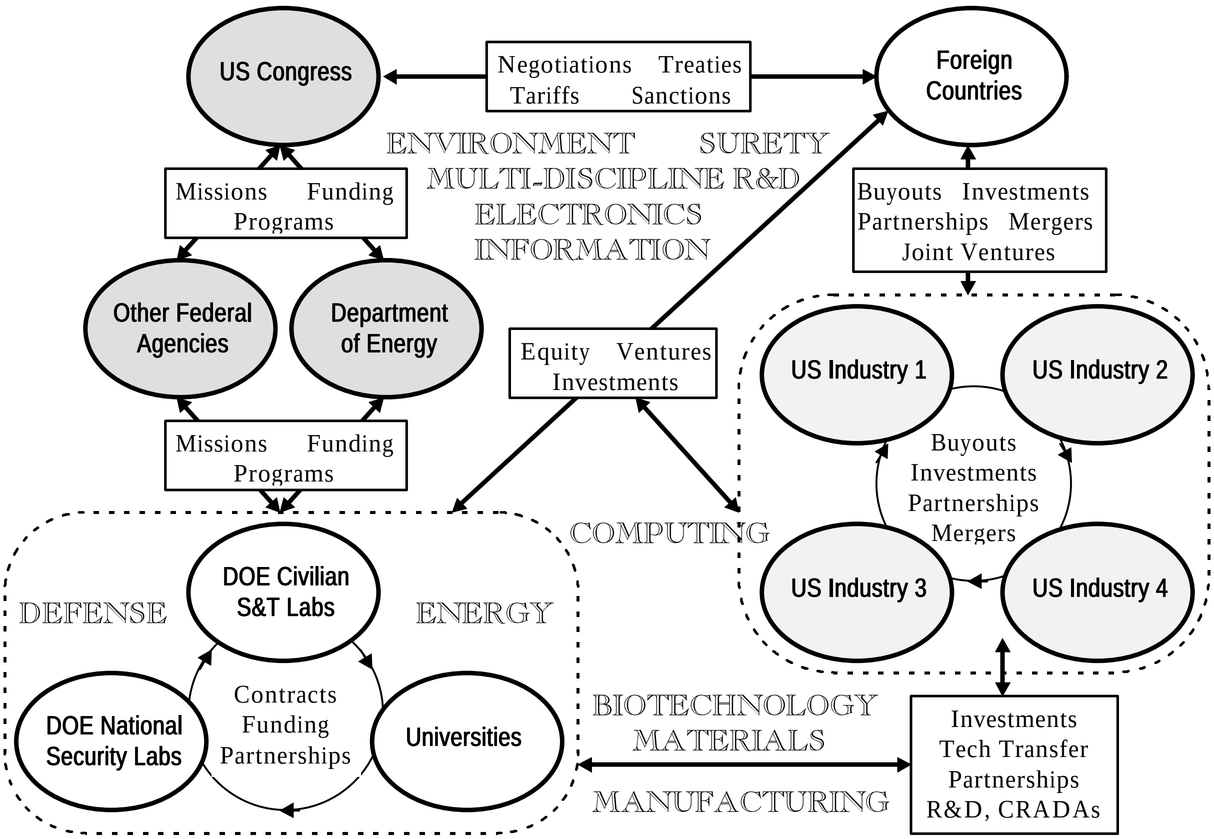

Figure 2. Some possible team interactions.

going through the normal (planning, negotiation and agreement) process.

The Toolkit is a list of technology and policy options that teams and players can invest in, which is provided in the game handbook. A copy of the Toolkit for this game is given in Appendix G. Teams are allowed and encouraged to add their own technology and policy ideas to the Toolkit. New options are announced to all teams after they are received and approved by the Control team.

Toolkit options cannot be bought outright. Success or failure of an option is determined by a probability calculation. Each technology and policy option (including new options submitted by players) is assigned a cost which yields a 50% probability of success, or a "50% cost". A larger investment in an option will increase the probability of success as shown in Figure 3.

Each team is given a special resource (money or credits) allocation that can only be used within the Toolkit. Toolkit allocations are meant to represent the relative influences of the different teams. Teams determine which of the technology and policy options are important for their desired futures or strategies. They invest their own resources and encourage others to partner with them, according to their priorities.

All Toolkit investments are required to be submitted by the end of Session 2. Any unused Toolkit resources are forfeited. After the investment decisions are received by the Control team, the individual investments are summed, and the probability calculation is done for each option to determine its success or failure. Probability calculations are only performed for those options where the investment meets or exceeds half the "50% cost."

For example, for an option with a "50% cost" of 100, an investment of twice this amount, or 200, would

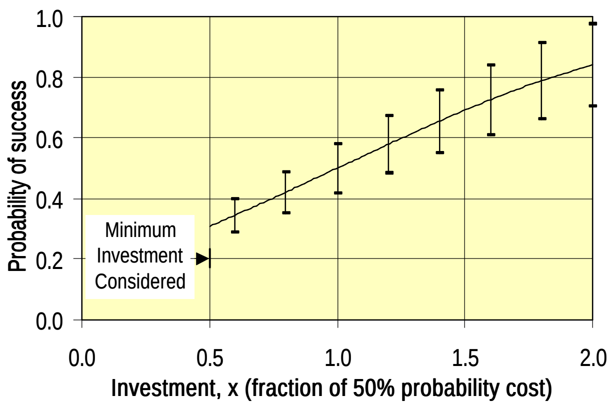

Figure 3. Probability of successful investment.

give a nominal success probability of 84%, as shown in Figure 3. This baseline probability follows a normal distribution with the standard deviation equal to the "50% cost." To take into account factors other than total investment, a uniform distribution is then superimposed on the normal distribution to reflect uncertainties and risks in the real world for accomplishing major technology or policy breakthroughs. This uniform distribution can increase or decrease the baseline probability by as much as 16%. The probability of success for investment in any option is thus its baseline probability multiplied by a random number between 0.84 and 1.16. To determine success or failure of the investment, a second random number is generated. If the new random number is less than the probability of success, the option is successful; if the random number is greater, the option is unsuccessful.

Toolkit options provide an indication of some possible advances in technology or policy that might significantly help a team accomplish its objectives. They are also meant to initiate and encourage collaboration among the many stakeholders. Many more Toolkit options are provided than can be invested in successfully with the resources available. Hence, teams should carefully consider which options are most important for accomplishing their objectives. Team selections indicate the highest priority technology and policy objectives of the players.

Negative investments are permitted for policy options. If a team strongly opposes a particular policy, a negative investment can make the realization of that policy less likely. Negative investments are deducted from the team's credits as if they were positive.

Some Toolkit investments involve joint ventures or partnerships among several stakeholders. For an option so specified to be considered, all involved parties must invest some funds in the option. The investments need not be equal. E.g., a joint industry-labs-university program must have some funds invested by all three teams to be accepted.

Money

After the Toolkit session was completed, teams were allocated money on a session by session basis. The money allocations to each team followed from the game designers' projections of the distribution of funds through the "food chain."Table 1 shows the baseline allocations to the teams for Session 3. Total funding was assumed to decrease by about 1.5-2% per year over the simulation. The money in the game was to represent national R&D expenditures only. Operating expenses and specific program-related R&D allocations were outside the focus of the game. All funding was to be treated as discretionary and available for investments during the game.

Table 1 allocations were based on historical and projected financial data, with modifications to suit the format of this simulation (see Appendix A).

The game design could have tracked the full process of taxation and distribution. However, because of time constraints and the possibility that one team's delay could completely stall the game, the preallocation method was selected. All teams were still expected to play their real roles and make any changes in the system appropriate to their roles and power. Hence, for example, the DOE could increase or decrease the discretionary funding to the labs; such changes would be implemented in the game in the following session. Similarly, Congress could increase or decrease the tax rate on industry, and this also would be implemented in the following session. Federal R&D funds could be increased or decreased in the game as a result of Congressional action with the approval of the President (Control team). However, such actions would entail real world consequences such as reductions in Medicare or increases in the deficit. The section on money in Appendix A discusses the allocation formulas used to create Table 1, and illustrates how interrelated all the teams are. The data and sources used to generate these funding and expenditure values are also available in Appendix A.

Table 1. Team allocations after "food chain" ($M).

Team	***Session 3 1998-1999***
US Congress	35
US Industry 1 (IT&AM)	455
US Industry 2 (E/E)	156
US Industry 3 (LS&AM)	156
US Industry 4 (NS&CJ)	156
Department of Energy	16
Other Federal Agencies	128
DOE National Security Labs	76
DOE Civilian S&T Labs	76
Universities	247
Foreign Countries	160
Totals =	**1661**

Foreign funds in this game represented investments by foreign-owned companies in US R&D. US R&D investments abroad were not considered here.

Results and Observations

Interpreting the Results

Acronyms

In the results sections, the acronyms used for each of the teams are given in Table 2.

Table 2. Team name acronyms.

Acronym	*Team Name*
C	Congress
IT/AMfg	Industry 1 (Info Technology and Advanced Manufacturing; I1)
E/E	Industry 2 (Energy and Environment; I2)
LS/AMat	Industry 3 (Life Sciences and Advanced Materials; I3)
NS/CJ	Industry 4 (National Security and Criminal Justice; I4)
DOE	Department of Energy
OFA	Other Federal Agencies
NS	DOE National Security (Weapons) Labs
S&T	DOE Civilian Science and Technology Labs; ER/EM
U	Universities
F	Foreign Countries

Nomenclature

There is also a nomenclature used to describe the various technology, policy, legal, and other types of agreements or options. Examples of these are:

T1, T2 … Technology Toolkit options (see Appendix G)

P1, P2 … Policy Toolkit options (see Appx. G)

N1, N2 … New initiatives introduced by teams during play; may be technology or policy oriented; involve probabilistic determination of a success or failure outcome (see Appendix E)

S1, S2 … Studies or other agreements not requiring probabilistic determination (see Appendix E)

L1, L2 … New laws written by Congress post-Toolkit (see Appendix E)

Roadmaps

All technology agreements and investments for the *Future@Labs.Prosperity* game were collected and analyzed in order to evaluate game play in terms of technology development interests, trends, and strategies. For the most part, a graphical display was chosen to illustrate the time lines and various linkages, much like a "roadmap." The data including these figures are provided below, and are arranged by the different technology fields used in the game. To help interpret the game play roadmaps, a legend is provided in Figure 4, with additional definitions in Table 3.

Strategy Levels

Discussions of team play and implementation of their strategies refer to several different levels of strategic planning. These levels, along with descriptions of their characteristics are:

Carpe diem! (Sieze the day) - Identification and rapid consummation of targets of opportunity or easy-to-reach agreements; separate; disjunctive; or-or reasoning; longest time horizon of 5 years.

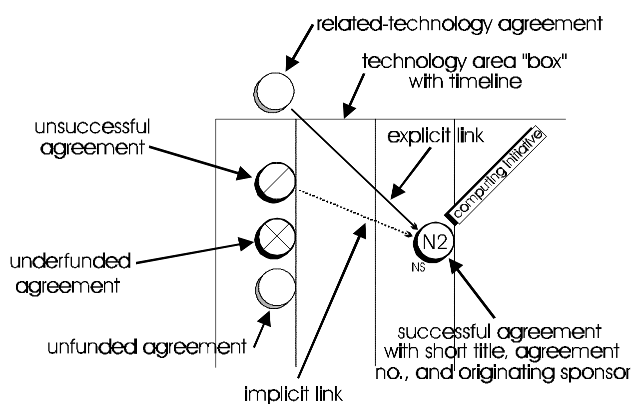

Figure 4. Symbols used in the game play roadmaps.

Table 3. Adjectives used to describe agreements in the game play roadmaps.

Agreement type	***definition***
unfunded	an agreement that was developed but not funded
underfunded	an agreement that was funded at less than the minimum required for possible success (25%)
unsuccessful	a funded agreement that did not meet the stated objectives (had at least a 25% funding level)
successful	a funded agreement that met the stated objectives
related-technology	an agreement executed in support of another technology field but that had synergistic elements

Partes pro toto! (Parts for the whole) - Several different agreements are negotiated, none of which is individually sufficient, but taken together they can succeed; connected; conjunctive; and-and reasoning; longest time horizon of 10 years.

Crescit eundo! (It grows as it goes) - Negotiation of series of contracts and alliances to meet predetermined needs; iteration of strategy as time progresses; serial processing; longest time horizon of 20 years.

Impetus futuro! (Force for the future) - Development of an initial robust strategy with negotiation of agreements to support and develop that strategy; development of contingency planning; parallel processing with cross-linking to external trends; synergistic; longest time horizon of 50 years.

Overall Summary and Objectives

Objective 1: Explore ways to optimize the role of the multidisciplinary labs in serving national missions and needs.

Since the primary products of the labs are new technologies and scientific advancements, the game was structured to explore the needs and priorities of the R&D community in eight major technology areas: information technology, advanced manufacturing, energy, environment, life sciences, advanced materials, national security and criminal justice. The Toolkit investments determined the players' priorities in technologies currently being investigated by the R&D community. Subsequent team-initiated investments and agreements tapped the creativity and priorities of the players as representatives of the different stakeholder communities: industry, government, universities, laboratories, and foreign governments and companies.

Forty eight technology R&D agreements received funding during the game. The largest dollar investments in the game were made in life sciences, information technology and energy (Figure 5, p. 13). Computing and networking technologies attracted very large investments in ten agreements, with all teams participating in at least one of the agreements (Table 4, p. 14). A war on disease and improvement of the transportation infrastructure also garnered about $750M in investments. Other major R&D efforts focused on food production, desalination and national security.

The teams' investments can also be compared to estimates of actual US total R&D spending (Figure 20, p. 34). These estimates and the total game investments were remarkably similar, considering the small sample of people and the artificial constraints of the game. However, the underlying investments illustrated some differences. E.g., the IT team itself (and the Foreign team) invested less in information technology and more in energy, environment, and life sciences than would be expected. However, this was compensated for by larger than expected investments in IT by many other teams (see Figure 6 and details in Appendix D).

Prosperity Games™ attempt to increase the sophistication of the players' strategies by encouraging decomposing a problem into its parts, thinking serially, and developing roadmaps with contingencies. The players were able to develop serial strategies in a few areas. For example, several teams developed a rough roadmap for computing and networking technologies that built on a national accelerated strategic computing initiative, including telemedicine, educational technologies, virtual reality, information surety, and low-cost internet access (Figure 7, p. 15). The players' agreements and investments were reconstructed into roadmaps, which are discussed on pp. 13-25.

Laws and policies have a potentially huge impact on the course of R&D. With industry and government R&D resources becoming more scarce, it becomes ever more important for these resources to be expended wisely if the nation is to continue to prosper. The teams strongly favored three policy areas: R&D tax credits, laboratory system governance / structure; and lab budgets.

There was a consensus that R&D tax credits are important and should be made permanent. However, opinions on the amount of the credit ranged from 10% to 100%. Some believed that all R&D work should receive tax credits; others favored credits for collaborative R&D between industry and federal labs or universities, or all industrial R&D outsourced to labs or universities.

Governance issues addressed lab consolidation and closure, creation of a system of labs, formation of Fraunhofer-like institutes, and authorization to conduct certain types of foreign R&D.

Two budget-related items impacted the game. Congress reduced the federal labs budget by 10%, and DOE changed its policy to promote partnering by eliminating funds-in taxes and allowing incremental cost recovery.

The Congress team also passed laws in pursuit of one of their main objectives: "To ensure that the United States is globally competitive." These laws dealt with trade initiatives, preserving critical industries, creating a Department of Economic Security, the Corporate Teaming Act, a Small Business Research Program, and reform of the Food and Drug Administration.

Although it may have escaped the attention of many players, the policies and laws approved and implemented primarily by the Congress team had a measurable effect on the distribution of game funds. Changes in tax laws and entitlements resulted in increased industry funds and decreased federal funds, but with an overall slight increase in total R&D funds over the course of the game. In fact, Congressional actions increased the R&D funds available more than did the industry returns on investment (Figure 21, p. 34).

Although many teams tended to ignore the external events, only the interplay between the Congress and Foreign teams managed to prevent a war that the game designers had preplanned. Another pre-planned disaster involving computer crime was also unknowingly avoided as a consequence of the heavy R&D investments in computing information surety.

Objective 2: Explore ways to increase collaboration and partnerships among government, laboratories, universities and industry.

This Prosperity Game™ was structured to encourage partnering among the various stakeholders, especially with the national labs. The two labs' teams were intentionally provided with very limited resources to encourage in-kind agreements and public / private investments that tapped the multidisciplinary R&D capabilities of the labs; the labs were not major sources of funding in the game.

In the early Toolkit investment session, the median number of partners was one; i.e., the investing team on average was able to obtain about one additional partner. In the subsequent sessions, the median number of partners tripled to three. (See Figure 18, p. 33). For several possible reasons, the teams began to see the advantages in attracting additional partners. One possible reason was to reduce risk by maximizing the investments from many partners. Another may have been to seek the additional skills and resources that would encourage the Control team to provide a lower estimate of the 50% cost. A third possibility is a recognition of the inherent advantages that partners bring to the table in terms of diversity, innovation, creativity, skills, common interests and synergies, and even political strength.

A "National R&D Summit Meeting" was conducted early on the third day of the game. The summit consisted of a panel of players, one from each team, who were to answer questions from the perspective of their teams. The questions were based on feedback from staff and players on previous actions, issues and perceptions. Since many teams had questioned the relevancy of the labs, this issue was raised as the first summit question. As a result of addressing this concern directly, play following the summit resulted in an increased level of laboratory participation, involving initiatives from most teams.

The second question dealt with ways to improve the National Technology Delivery System including appropriate metrics. The third question dealt with clean, inexpensive sources of energy, especially for transportation. Details are presented on pages 35 - 39.

Several policies were proposed to encourage partnering. These included various tax credits and incentives, as well as a corporate teaming act which amended anti-trust laws to permit more partnering.

The different teams were assessed on their willingness to partner and the correlation between partnering and team success (Appendix D). They were also scored on creativity, belief in their own objectives, the importance of a team's agreements to the game as a whole, and the sophistication of their strategies. Most teams were quite successful, including some that fought the game construct and assumptions. Partnering was extensive.

Six metrics were subjectively tracked over the course of the game to estimate the players' impact on the health of the nation's economy, quality of life, and defense readiness (pp. 39-42). Despite setbacks in the early out-years, improvements over baseline projections were noted eventually in all areas except the trade deficit (a consequence of the success of the foreign team).

Objective 3: Create a network of partnership champions to promote findings and policy options.

Perhaps the most stunning success of the Prosperity Game™ has been the commitment of many players to follow-on activities. As part of the game, the players were asked for their suggestions for ways to accomplish the game objectives through additional post-game efforts. The suggestions of the players and the other ideas that originated in the game are presented on pages 43-46.

The game planners have conducted meetings to develop committed champions and a set of tasks and areas to be pursued. Eight follow-on self-directed teams have been formed: DOD/Lab Interactions; National System of DOE Labs; Public Affairs; Marketing; University/Lab Partnerships; Government Interactions; International Programs; and Industry/Lab Partnerships. All teams have a pair of lab and private sector people helping to guide their activities.

Technology R&D Initiatives

Summary

Technology R&D initiatives involved a total of 48 agreements and $7594M during the course of the game. All of these agreements were categorized into one of seven major technology areas, which were then subdivided in order to provide further details of the R&D pursued during the game. The results are provided in Figure 5. As can be seen, investments were not level across the playing field, but exhibited a strong tendency toward life sciences, information technology, and energy. Team-by-team interests also varied considerably across the different technology fields, as shown in Figure 6, although this trend was more pronounced, as expected, between the different industry teams. (A comparison of game investments vs. real life can be found in Appendix D.)

If details of the game plays are considered in terms of apparent interests of the players (total invested in sub-technology areas), a slightly different focus is noted, as summarized in Table 4. The largest cumulative investments were made in the field of computing and networking technologies, with all teams participating in at least one of the agreements. This activity included work in the virtual workplace (T5), information surety (T4, T36, N15), a national

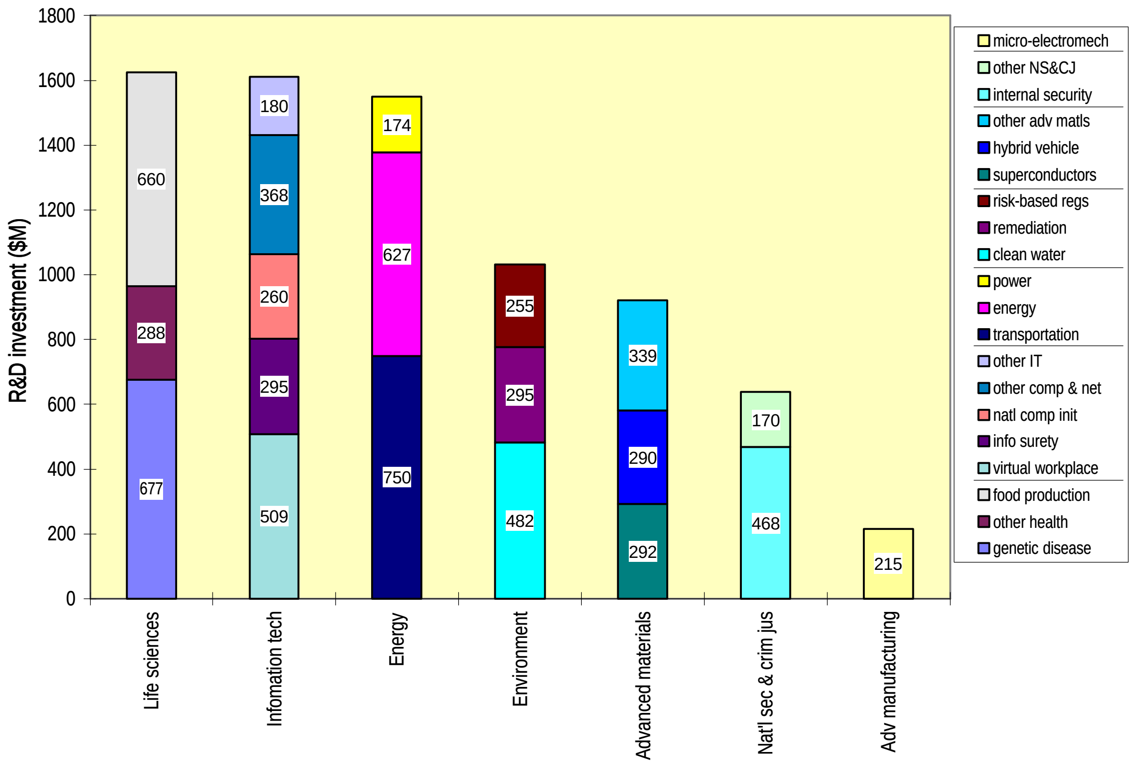

Figure 5. R&D investment summary by technology area.

computing initiative (N2), and other related work in ASCI (T1, T3), education technologies (N4, N16), and low-cost internet access (N24). Although not included in the table summary, $175M in related IT work was conducted in the area of medical software (T20) and telemedicine (N1). As another measure of the importance of computing and networking technologies on the game, consider the next two entries in Table 4. Second on the list is a "war" on disease that represents a broad interest in developing cures for genetically pre-disposed (N26) and viral (N34) diseases. Both of these agreements built on completion of the human genome mapping project (anticipating real life) and the advances in computing and related IT made during the game. Although not explicitly discussed in the agreements, the third interest area, transportation infrastructure, also would have been enabled by the advances in IT. This would include the advanced controls found in the high-speed mass transit (N18) agreement, the modeling and simulation required for increased utilization of the existing infrastructure (N27), and the development of an intelligent ("Smart") transportation infrastructure (N33). Other high-interest areas included: use of biotechnology for increased food production (T23, N32, N37); production of a plentiful clean water supply through advanced desalination technologies (T17, N22); and application of NS Labs' capabilities toward solving internal US security concerns (T33, N12).

Technology Area Roadmaps

Information Technology and Advanced Manufacturing Initiatives

The primary thrust in the Information Technology and Advanced Manufacturing (IT/AMfg) field during the game was in the area of computing and networking. Activities in this area are shown schematically in Figure 7, with additional funding details in Table 5. Advances made and lessons learned from a diverse set of Toolkit investments ($714M, including $75M expended in related telemedicine work) were folded into a single, successful national initiative ($260M)

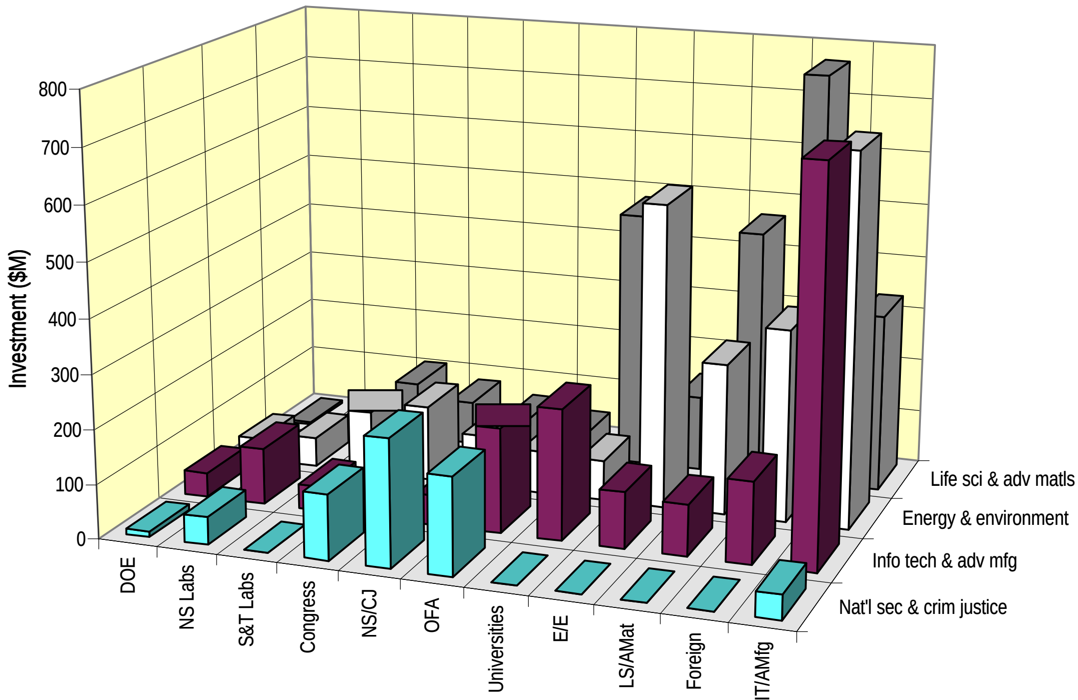

Figure 6. Team spending summary by technology area.

with participation by most teams. Follow-on work in advanced information surety (IS; $225M) presumably built upon previous IS activities of the Toolkit and national initiative. Significant expenditures were also made in technologies to enhance education and training ($268M), with the capstone being a virtual reality system that provides immersion training to the student(s). The final work in the information technology (IT) field as applied to computing and networking was a $40M R&D effort that provided a low-cost (<$100) Internet access machine, effectively enabling web access to most of the US population. One successful non-computing IT initiative (N9) was supported ca. 2000 to develop "smart buildings" that would provide both energy management and safety/security oversight roles. IT was also critical in enabling other technology thrust areas (e.g., an intelligent transportation infrastructure) that are discussed under the respective technology areas.

Table 4. Primary R&D investment areas.

	Total invested ($M)	*No. of agrements*	*No. of teams*
Computing & networking	1432	10	11
War on disease	764	2	10
Transportation infrastructure	750	3	10
Biotech for food production	660	3	3
Clean water by desalination	482	2	7
Internal US security	468	2	6

The only advanced manufacturing activity was a broadly supported initiative (N29; $215M) led by the weapons lab team ca. 2003. This R&D effort used the next generation of micro-electromechancial systems to revolutionize electronic component and system assembly and integration technologies.

Further descriptions of the IT/AMfg agreements follow below.

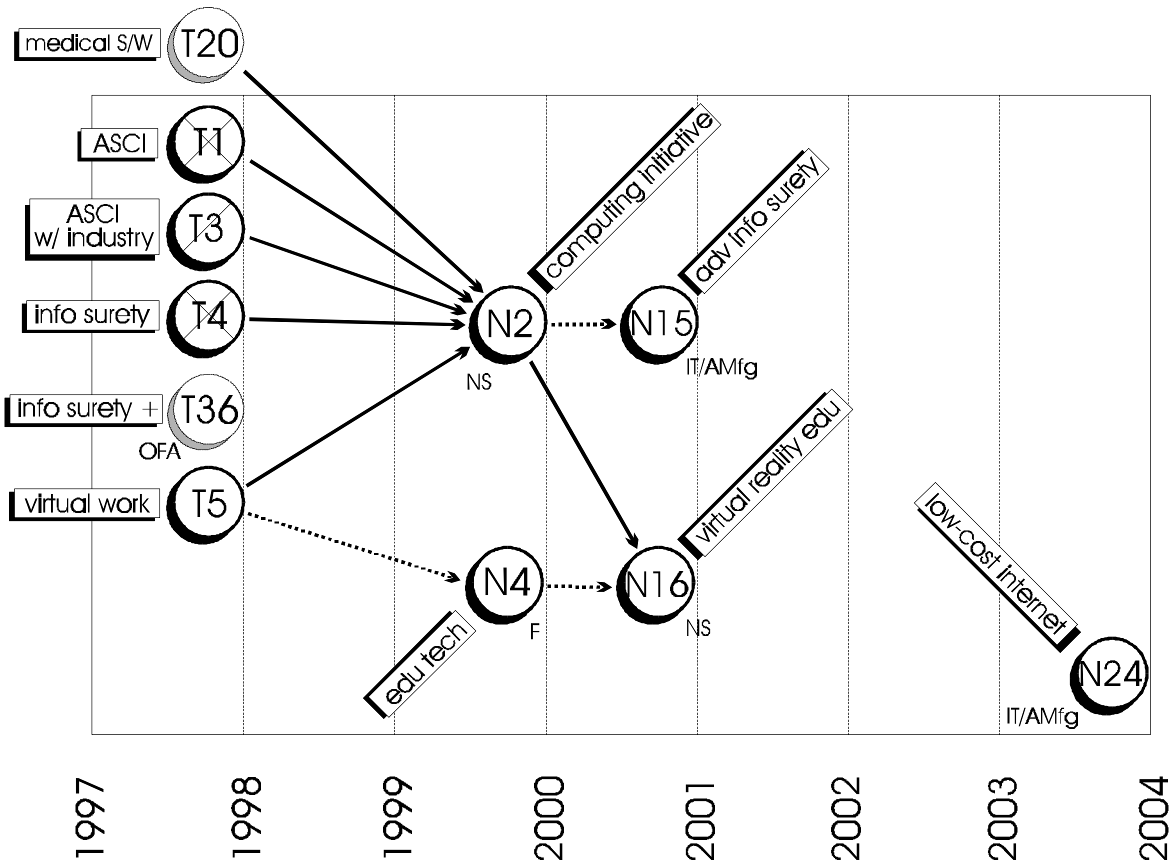

Figure 7. Computing and networking technology R&D roadmap.

Table 5. Computing and networking investment portfolio.

Option number	*50% probability*	*US Congress*	*IT/AMfg*	*E/E*	*LS/AMat*	*NS/CJ*	*US DOE*	*US OFA*	*Universities*	*NS Labs*	*S&T Labs*	*Foreign Team*	*Total invested ($M)*
T1	200								10				10
T3	50						20			30			50
T4	150	70											70
T5	250		250	49			20	100	50	10	10	20	509
T36	200												0
N2	200	10	50			50	5	25	50	35	35		260
N4	150							10	100			90	200
N15	150		140		50				20	15			225
N16	50		25					28	5	10			68
N24	20		20	5	5	5			5				40

T1/T3. Accelerated Strategic Computing Initiative (ASCI)

This initiative was continued (linked to current real-life activities) with a total of $60M invested, although the goal of developing a 15 teraflops machine was not achieved. The university team expended $10M in an isolated effort on the basic T1 Toolkit, a level of funding that had no chance of succeeding. DOE and the Weapons Labs (National Security Labs) teams expended the other $50M on T3 in a bid that failed to package ASCI in a way that would lure industry into contributing funding and expertise to the effort.

T4/T36. Information Surety (IS)

A major new program (T4) was launched to ensure the integrity and security of the national information infrastructure and telecommunications system to protect both government and business transactions. This effort was funded at a level of $70M by Congress, a level that was insufficient to provide any chance of success. The Other Federal Agencies (OFA) team expended considerable effort in planning an IS activity (T36) applicable to the *global* information infrastructure, but was unable to raise any R&D capital.

T5. Virtual Work Environments (VWE)

The largest Toolkit program funded in the game was the successful R&D effort in virtual reality. This program had the broadest support (eight participating teams) and had the highest funding level ($509M, which was 18% of the available Toolkit resources; compare the 50% success probability funding level of $250M). Advances were made in bandwidth, software, and related technologies allow virtual work environments to become practical with applications to the workplace and education. The results of this project were explicitly recognized and used as a tool in later R&D efforts (e.g., N5, Hybrid Vehicle Materials Development).

N2. National Computing and Networking Initiative (NCNI)

The NCNI was a successful eight-team/$260M program that built on and integrated previous ASCI/IS/VWE results and lessons learned, resulting in a secure, high-capacity and high-bandwidth computing network. The results enabled the use of virtual reality and modeling/simulation tools in a reasonably secure environment across the US network for R&D, business, and educational purposes.

N4. Technology for Education (TFE)

This program developed and deployed new technology specifically focused on public and worker education, with a focus on educational content development. The total investment was $200M by the OFA, Universities, and Foreign teams. This agreement represented a modified version of Toolkit option T6.

N9. SMART Buildings

A consortium of US and foreign entities partnered to develop "smart buildings" that provided energy management and safety/security oversight roles. This effort included development of the necessary software and hardware (including specialty chips and advanced wireless communication capabilities). It was envisioned that the system would control all energy sources in buildings and factories, including heating, cooling, and lights in order to "significantly" decrease energy costs. In addition, the system would link to security systems with enhanced monitoring of video and audio coverage of the building, reducing the possibility of theft, fire, and other damage. The SMART program was funded at $180M, twice the 50% probability of success cost, with contributions by Industry 1 ($110M), Industry 2 ($50M), OFA ($10M), and the foreign team ($10M).

N15. Advanced Information Surety (AIS)

Although IS was a part of NCNI, four teams believed that the initiative did not advance the state-of-the-art beyond the 20th century, and thus did not meet future needs. (Recall the IS Toolkit (T4) was not adequately funded, and the funding of NCNI was not at a level to make major advances in all areas.) Basically, the AIS program fulfilled the original IS Toolkit goals, as enabled by proper funding levels ($225M).

N16. Virtual Reality Trainer (VRT)

This initiative developed a total immersion training tool which is realistic and interactive. For example, it allows: people to perform their work in foreign language settings; soldiers to train on the battlefield; industrial workers to achieve training without risk (to themselves and the equipment); executives to test "out-of-the-box" strategies ("Prosperity Games on-line"); etc. This was a $68M program with four sponsors that presumably built upon the previous VWE, TFE, and related efforts.

N24. Low-cost Internet Access Computer (LIAC)

The LIAC program developed a low-cost personal computing device that broke the $100-per-unit price, effectively enabling its purchase by almost the entire US population. This $40M program was sponsored by all four industry teams and the university team.

N29. Advanced Micro-electromechanical Manufacturing (AMM)

AMM was a broadly supported initiative that utilized the next generation of submicron microtechnology (micro-electromechanical systems) to revolutionize electronic component and system assembly and integration. The total program was funded at $215M (compared to the $100M 50% probability for success cost), with $120M from Industry 1, $40M from Industry 4, $20M from OFA, $1M from the universities, $4M from the weapons labs, and $30M from the foreign team.

Energy Initiatives

Technologies pursued within the energy field during the game were in three general categories: power, energy supplies or sources, and transportation. A total of $1548M was spent on energy related R&D activities. Of this, $171M was spent in the area of power; one related technology was deployed as a result of $121M that was spent in a successful bid to improve the capacity of the electrical transmission network (power grid). In the area of energy supplies or sources, $627M was invested in a variety of options; advanced batteries had the largest investment ($331M) that was received from a broad constituency (8 teams). However, investments in the transportation network received the most attention in the *Energy Initiatives* category, with $750M going to R&D in high-speed mass transit, infrastructure modeling and simulation, and in an intelligent infrastructure. Agreement actions are displayed in a graphical format in Figure 8. From this chart it is not apparent that there was any coherent strategy among the energy initiatives, with the only synergistic work being implied within the transportation infrastructure area ($550M total). Additional details of the energy agreements can be found in Table 6 and in the summaries that follow below.

T11. Improved Gasoline Fuel Efficiency

Gasoline use efficiency was increased by 10% on a nation-wide basis. This program was sponsored by DOE, but was funded primarily by matching funds between the E/E industry team and Congress.

T12. Alternative Vehicle Fuels Program

The DOE initiated a program to develop alternate fuels for use in vehicles. However, only the initial program development phase was completed ($5M), with the bulk of the estimated funds required for reasonable success never materializing. (an additional $295M).

T35. Nuclear Power Plant Service Life Extension

To try to utilize its weapons life-extension work in a synergistic way, the DOE National Security Laboratories, with Congressional support, teamed with the E/E industry team to perform the R&D necessary to extend nuclear power plant service life. Although funded at a 50% success probability level, this activity failed to develop the necessary tools or technology to be considered a success.

N3. Non-LWR Nuclear Power Plant Study

In an effort to renew the nuclear-power option in the US, the E/E industry teamed with the DOE lab complex to conduct a three-year study of the efficiency, economics, and safety of non-light water reactors. Although the study was successfully concluded, no technologies or specific programs resulted from the work.

N7. Deep-water Oil & Gas Production Technology Program (DOGaPT)

In a successful effort to increase the operating water depth of off-shore oil platforms in the Gulf of Mexico by 200 feet, the E/E industry teamed with universities and the DOE lab complex to develop the necessary technologies. The results of the DOGaPT program are conservatively expected to enable commercial access to another 100-million barrels of domestic oil.

N8/N19. Advanced Batteries

Recognizing the need and market, the DOE lab complex, Other Federal Agencies, and all four industry teams participated in a consortium to develop advanced (long-life, light-weight) batteries. The approach used was to select materials and designs capable of being scaled, rather than one of individual application-specific design. The performance goals achieved included a 20-hour laptop computer battery, and a suitable candidate battery for a 150-mile range personal electric vehicle.

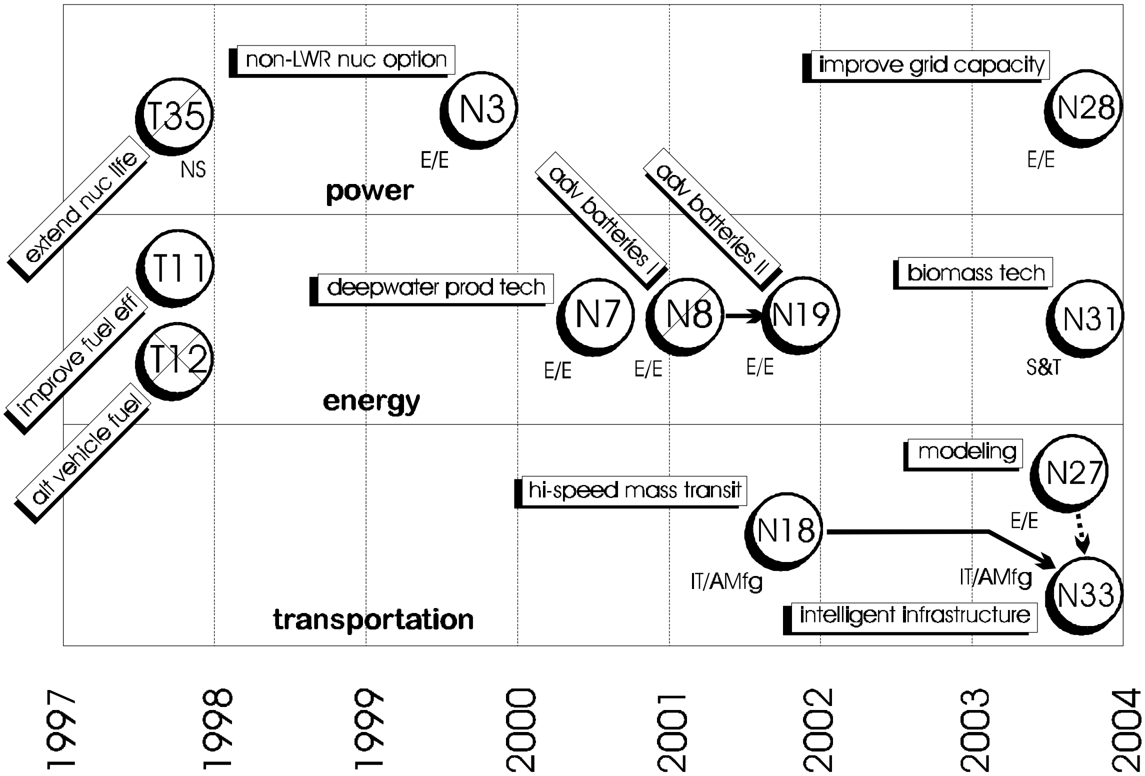

Figure 8. Energy initiatives roadmap.

Table 6. Energy initiatives investment portfolio.

Option number	50% probability	US Congress	IT/AMfg	E/E	LS/AMat	NS/CJ	US DOE	US OFA	Universities	NS Labs	S&T Labs	Foreign Team	Total invested ($M)
T11	50	50		50			5						105
T12	300						5						5
T35	30	15		15									30
N3	10			10						5	5		20
N7	15			20						4	4		28
N8	200		105	105	50	31		10		6	5	10	322
N18	100		120	10	60			10					200
N19	1			9									9
N27	100	10	100	50	10	20		5	5	1	5	5	211
N28	60		50	22	10			14			5	20	121
N31	80	10	100	20							8	20	158
N33	200	10	100	20		45		10	30	9	15	100	339

N18. High-speed Mass Transit Program ("Fast Track")

The Fast-Track program successfully developed the necessary controls, materials and design to enable deployment of a high-speed mass-transit system in the high-density corridors found along the US East Coast. The results were stated to provide "much faster" speeds and greater passenger comfort than existing options, and Fast Track is expected to be competitive even in Europe. This program was one of four *Energy Initiatives* funded at the $200M+ level, with primary backing by special appropriations by Congress, and additional funding from OFA, and industry teams 1 & 2.

N27. Surface Transportation Modeling and Simulation Program (STMS)

STMS was a program geared toward increased utilization of the existing US transportation infrastructure through more effective/efficient usage. The results of the program are expected to reduce transportation-related energy and air pollution costs by 10% over the 10-year post-program period projections. All teams except DOE participated in this successful effort.

N28. Improved Electrical Grid Capacity (IEGC)

With the expected upcoming deregulation of the electrical power utilities, significant changes in the power grid will take place. Use of existing technology will likely result in expansion or re-routing of current "high-lines." The IEGC program was a successful R&D effort to develop and introduce a variety of power conductors and other technologies necessary to increase the carrying capacity of existing lines that will offset some of the expansion or re-routing otherwise envisioned.

N31. Biomass Technology Deployment ("NOVO" Power)

Under this initiative, the biomass technology assets of ORNL and NREL were privatized under sponsorship of Congress and the DOE S&T lab system. US industry teams 1&2, along with some foreign support, set up a commercial entity based upon these privatized assets, which is expected to develop biomass technologies to the point where biomass fuels and power will become significant options in three years.

N33. Intelligent Transportation Infrastructure ("SMART")

The largest single agreement within the *Energy Initiatives* was a nine-team successful effort to develop and prototype a non-traditional transportation infrastructure that utilized innovative technology. Deployment is planned to be world-wide, and is expected to have positive impacts on energy consumption and environmental protection. Although this effort was not explicitly linked to N27, the previous effort in infrastructure modeling and simulation was seen as a necessary under-girding for the SMART system.

Environmental Initiatives

Environmental initiatives ran about 'mid-pack' of the different technology areas tracked in the game when it came to attracting money, with a total of $1032M spent on six different agreements or Toolkit options. All teams except the NS/CJ Industry supported at least one environmental project. These initiatives took the form of three thrust areas: risk/cost-based regulations; water desalination; and in-situ environmental remediation. Each thrust area was supported by seven teams. The thrust area receiving the most funding was the water desalination project, at a total of $482M (no. six in overall game terms). Remediation agreements, by comparison, raised only $295M. Finally, the development of a risk/cost-based regulations methodology raised $255M (which was 2.55 times the 50% chance-of-success value). A timeline illustrating linkages between these agreements is provided in Figure 9. Further investment details are provided in Table 7.

T17. Clean Water Initiative

A Global Clean Water Initiative was funded to cheaply convert sea water to fresh water. This successful project included evaluation, risk/cost analyses, engineering, and prototyping. Although only five teams participated in this option, it drew the most money in its category (environment).

T18. Risk/Cost Based S&E Regulations

A risk/cost basis for analysis of safety and environmental regulations is developed and widely accepted for use. Seven teams participated in this effort.

N6/N11. Environmental Remedial Technologies

This project developed three specific technologies suitable for commercialization. These were: in-situ hydrocarbon remediation; in-situ heavy metals remediation; and in-situ radioactive materials remediation. The initial effort by the E/E industry and S&T labs was not successful with a $30M investment. After attracting DOE and the NS Labs as partners, and raising an additional $50M, this project

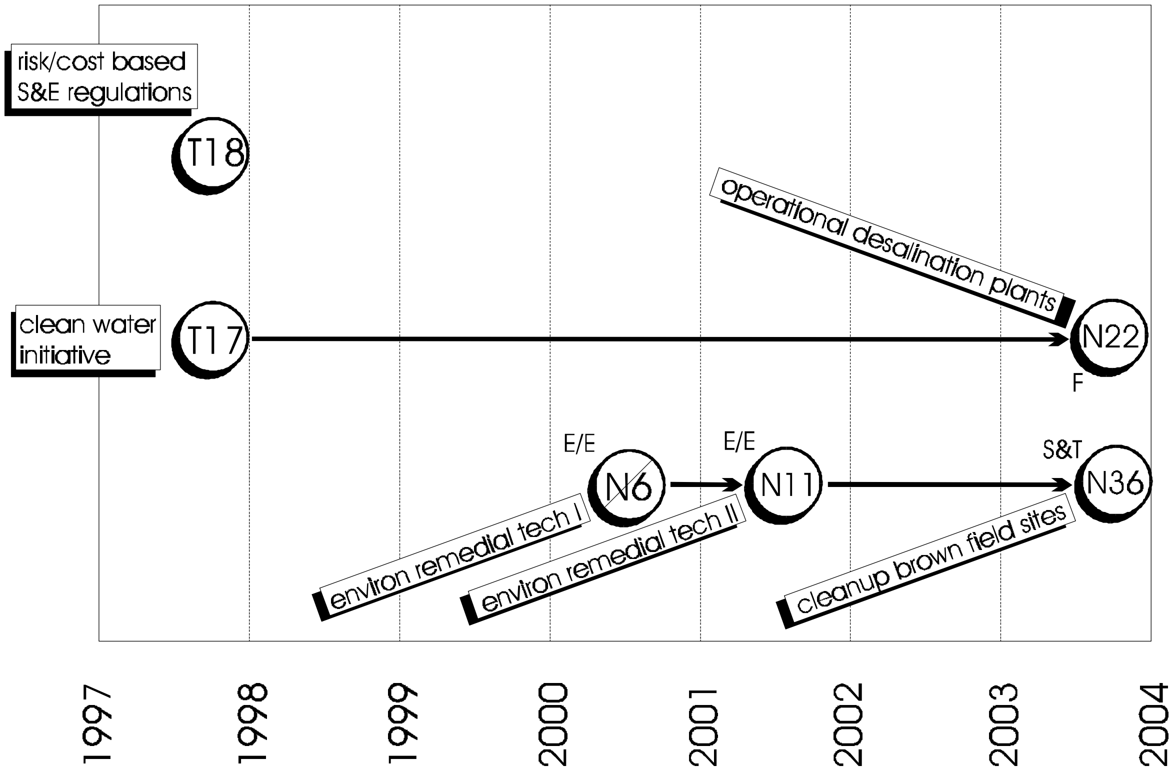

Figure 9. Environmental initiatives roadmap.

successfully demonstrated in-situ remediation techniques.

N22. Operational Desalination Plants

The activities under this agreement included the necessary development to take the technologies originated under the Clean Water Initiative (T17) and deploy actual operational plants in the Mideast.

N36. Brown-field Site Remediation

In order to clean up inner-city neighborhood “brown-field” sites and allow expansion of manufacturing, in-situ remediation technologies developed earlier (N6/N11) were adapted. This included the necessary development to meet the specific requirements associated with this task. LS/AMat Team participation included a $35M loan from the World Bank.

Table 7. Investments in environmental initiatives.

Option number	50% probability	US Congress	IT/AMfg	E/E	LS/AMat	NS/CJ	US DOE	US OFA	Universities	NS Labs	S&T Labs	Foreign Team	Total invested ($M)
T17	300	30		49					20	3		180	382
T18	100	10		87	100		25		10	3	20		255
N6	20			20							10		30
N11	20			20			5			15	10		50
N22	50		60						10		10	20	100
N36	75	5	50	55	50			30		5	20		215

Life Science Initiatives

Initiatives under the Life Sciences category represented the largest investments in the game, both in terms of total dollars ($1625M) and in terms of the single largest agreement ($677M). Two broad thrusts within the life sciences field can be identified: health and food production. The $677M agreement was a University-led effort involving ten teams that

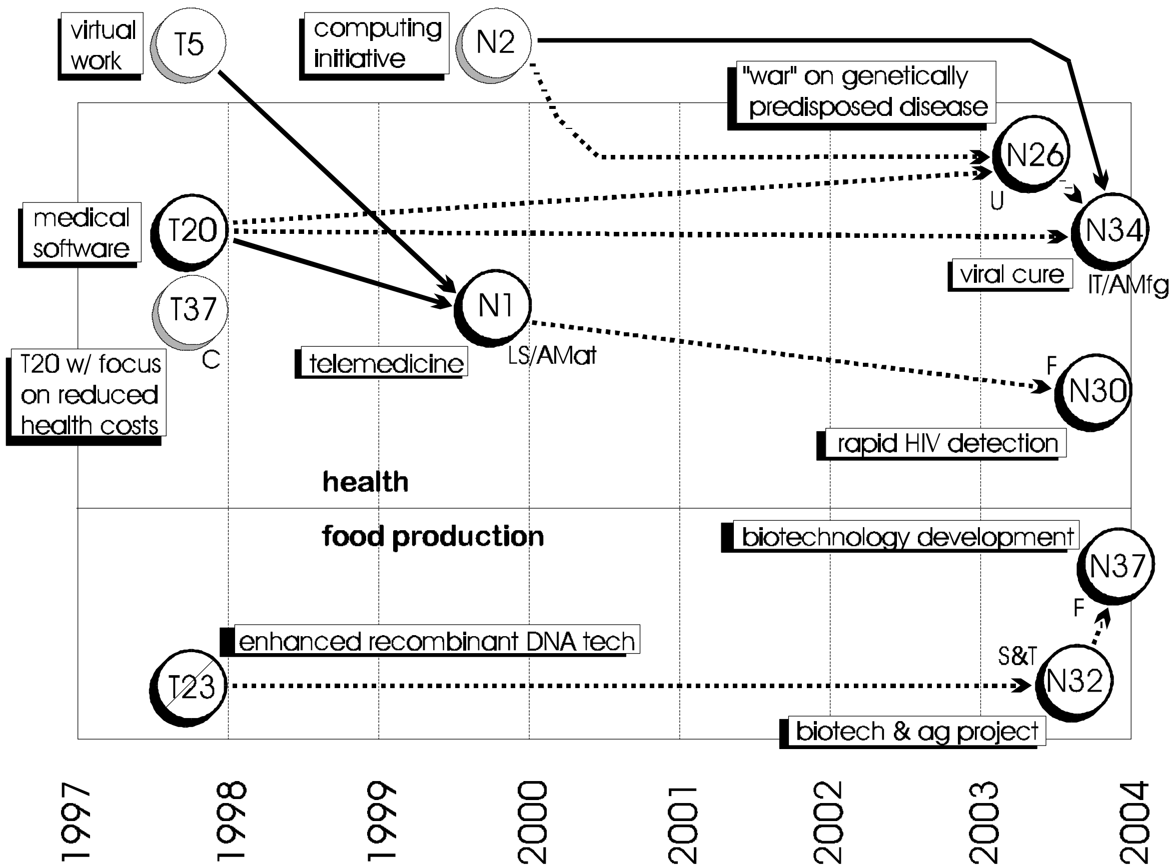

Figure 10. Life Science initiatives roadmap.

Table 8. Life Science initiatives investment portfolio.

Option number	*50% probability*	*US Congress*	*IT/AMfg*	*E/E*	*LS/AMat*	*NS/CJ*	*US DOE*	*US OFA*	*Universities*	*NS Labs*	*S&T Labs*	*Foreign Team*	*Total invested ($M)*
T20	60	40							25		10		75
T23	200											100	150
T37	70												0
N1	50		40		40							20	100
N26	500	31	110	35	20	50		15	334	10	22	50	677
N30	20			1								25	26
N32	50		10								10	90	110
N34	30	5	45		10			1				26	87
N37	200											400	400

developed techniques to cure genetically predisposed diseases. Other health initiatives totaled $288M, with a focus on medical software and telemedicine. Food production issues primarily focused on biotechnology, and had a total of $660M in investments. Linkages between various agreements are illustrated in Figure 10. Team contributions to the various agreements are provided in Table 8.

T20. Medical Software

A joint industry-labs-university program was funded to develop software for diagnosis, epidemiological studies, remote consultation and diagnosis (telemedicine), and health management, and to place these tools on the Internet with secure technology.

T23. DNA Technologies for Food Production

Research in enhanced recombinant DNA technologies increases food production by 20% in the US and by 100% in developing nations.

T37. Medical Software II

This approved but unfunded option was developed by the Congressional Team. The project's focus was a modification to T20 that was to develop medical software with a focus on reducing health care costs and paperwork, and on improving patient information and services.

N1. Telemedicine

This project built on the successes of T5 and T20 (e.g., bandwidth and software). It successfully demonstrated a system and set of standards for telemedicine, diagnosis, and health management. The system represented improvements in and integration of software, hardware, sensors, and telecommunications.

N26. War on Genetically Predisposed Diseases

This agreement represents the single largest agreement in the game ($677M), and one of three that had ten investors (only DOE did not participate). The project successfully executed under this agreement developed the causal relationship between genetic composition and diabetes and Alzheimer's disease. The results also provided the scientific foundation for applying research to other diseases.

N30. HIV Detector

An HIV detector is developed that can provide test results within a few minutes. The resultant technology is suitable for packaging in a small, rugged and portable instrument to enable world-wide use.

N32. Biotechnology and Agriculture Project

Activities under N32 developed sensor and instrumentation suites for measuring soil moisture, constituents, and fertilizer/pesticide residue levels. Products utilizing these technologies are expected to enable improved food production and reduced consumption of water, chemicals, and energy.

N34. Viral Cure

Advances in modeling and simulation are utilized in understanding viral interactions in the human body, and result in the development of a cure for an emerging viral threat in Third World countries. LS/AMat Team participation was made possible by a loan from the World Bank.

N37. Biotechnology Development

Advances in biotechnology are further developed with specific application to the needs of Canada and Europe. This project was made possible by a loan from the World Bank.

Advanced Materials Initiatives

Two initiatives stand out from among all of those in the advanced materials area on the basis of total investment as well as partnering. These are the hybrid vehicle materials agreement (N5; $290M; 7 partners) and the room-temperature superconductors agreement (N23; $292M; 10 partners). Sequencing and investment details are provided in Figure 11 and Table 9.

T24. Smart Materials

A joint industry-labs-university program is launched to develop smart materials for construction and manufacturing that give visible or audible warnings when they become unsafe.

N5. Materials for Hybrid Vehicle

This agreement built on Toolkit Option T11, using virtual workplace technologies developed by T5, to develop materials to support increased fuel economy, low emissions, and recycling in vehicles. Specifically targeted for development were: (1) catalytic fuel cracking high-yield processor; (2) light-weight composite materials that are recyclable; (3) hybrid processing changing from fuel to battery power [sic]; (4) light weight battery.

N10/N20. High-temperature Materials

This effort focused on the development of materials for improved efficiency, reliability, and performance in automotive engines, industrial turbines, metals manufacturing, rocket engines, and aircraft turbines.

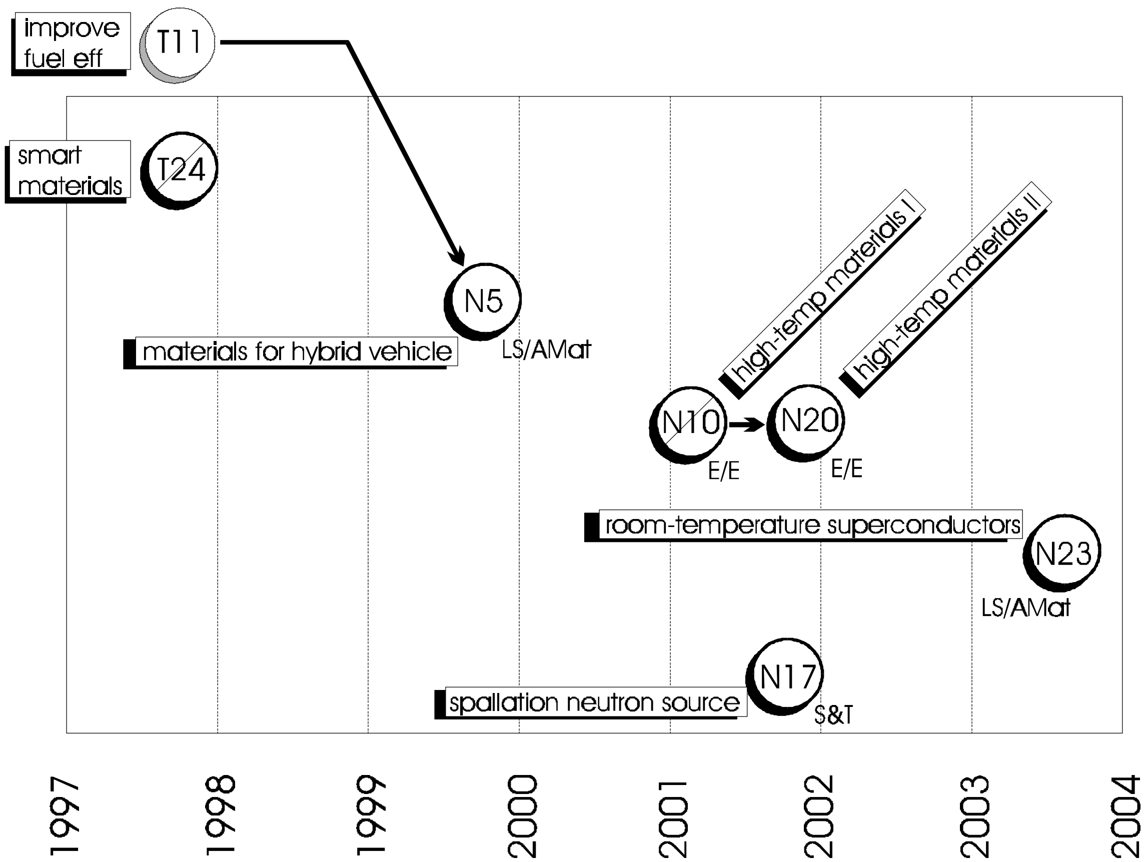

Figure 11. Roadmap illustrating advanced materials initiatives.

N17. Spallation Neutron Source

This agreement involved the development of a short-pulsed neutron source to support advancing the state-of-knowledge of high-temperature materials. The source was also expected to be suitable for the study of biological processes.

N23. Room-temperature Superconductors

Under this program, room-temperature (300 K) superconductors were developed that displayed long-term durability and were suited for manufacturing by a continuous process. It was expected that the cost of this material would be no more than three times that of conventional materials.

Table 9. Investment summary by team for advanced materials initiatives.

Option number	*50% probability*	*US Congress*	*IT/AMfg*	*E/E*	*LS/AMat*	*NS/CJ*	*US DOE*	*US OFA*	*Universities*	*NS Labs*	*S&T Labs*	*Foreign Team*	*Total invested ($M)*
T24	100				130								130
N5	250		50	5	100			5	100	5	25		290
N10	100			55	30			10			10	45	150
N17	50	5	5	5	5				5		25		50
N20	1			9									9
N23	200		70	30	130	10	5	10	16	6	5	10	292

National Security and Criminal Justice Initiatives

The primary thrust of the agreements in the NS/CJ area was toward use of the NS Labs in improving the internal security of the US. In aggregate (T33/N12) some $468M (73% of total) was spent with this

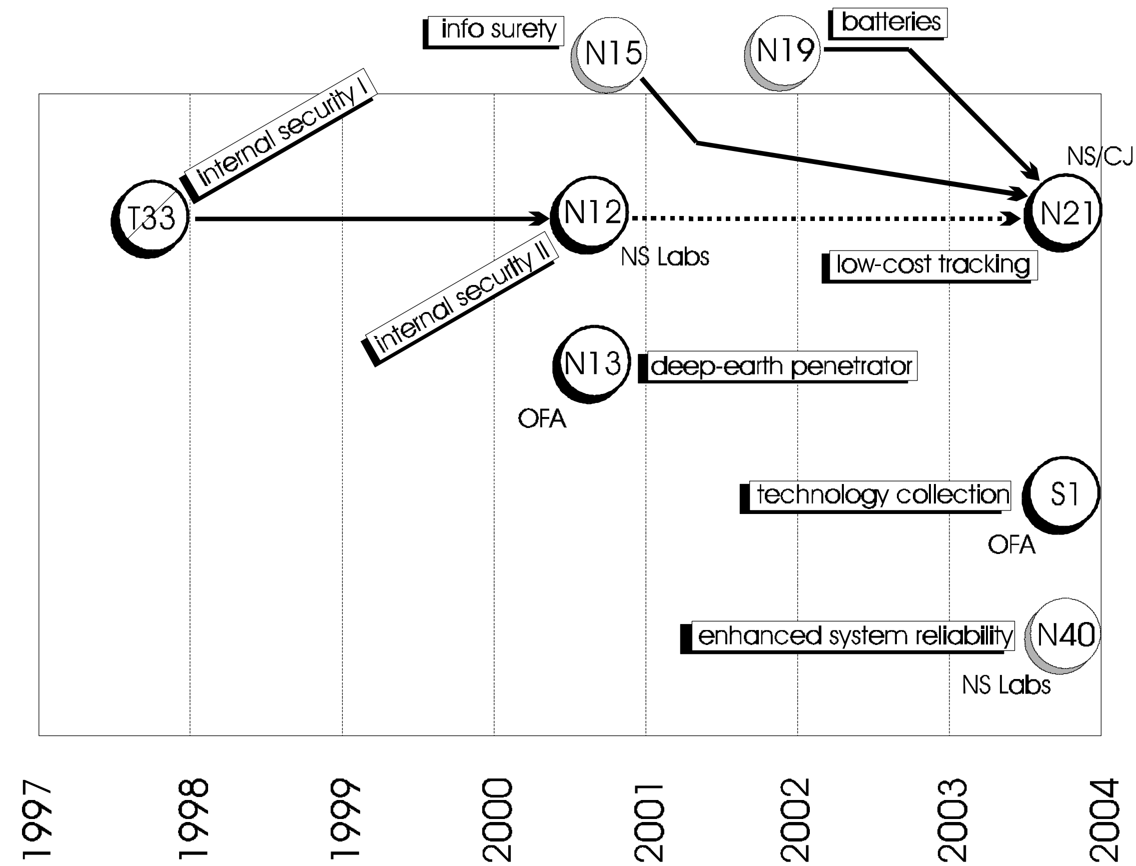

Figure 12. Roadmap for NS/CJ agreements.

focus. Further details of the NS/CJ agreements can be found in the text below, with connectivity and time information illustrated in Figure 12, and with investment details summarized in Table 10.

Table 10. Investment details for NS/CJ agreements.

Option number	*50% probability*	*US Congress*	*IT/AMfg*	*E/E*	*LS/AMat*	*NS/CJ*	*US DOE*	*US OFA*	*Universities*	*NS Labs*	*S&T Labs*	*Foreign Team*	*Total invested ($M)*
T33	300	100						50					150
N12	180	20	25			153	10	80		30			318
N13	50							40		10			50
N21	50		20			80							100
N40	60												0
S1	n/a							9		11			20

T33/N12. Internal Security

A new program is launched to use the labs' technology capabilities to enhance the security and safety of citizens from internal threats like crime and terrorism, including the use of unconventional warfare. The technologies developed included enhanced deterrence, detection, tracking, defeating, and protecting against such threats. The labs worked with agencies with relevant statutory missions including the CIA, FBI, and DOD.

N13. Deep-earth Penetrator

This program was a design-only effort to develop a highly-accurate, low-yield, deep-earth penetrating nuclear weapon. Not only was this effort envisioned to enhance national security, but it was deemed as essential in order to maintain the experience level of new weapon designers at the national labs, and to resolve part of the aging US nuclear weapon stockpile problem.

N21. Low-cost Tracking

Efforts under this agreement developed a suite of low-cost sensors for use in asset/safety tracking systems. The remainder of the system utilized advances in power sources (N19), information/telecommunication security (N15), and software development tools. It was envisioned that the sensor packages would be utilized across a broad market including use in prisoner tracking, child tracking, and materials security.

N40. Enhanced System Reliability

This agreement was developed late in the game and did not receive funding before completion of play (although commitments had been made by at least three teams) . The agreement intended to increase the reliability and extend the life cycle of complex weapon systems through enhanced surveillance. The surveillance systems were envisioned to make use of extensive sensor and electronic communication systems. Long term usage was envisioned for the commercial sector in equipment ranging from appliances to cars.

S1. Technology Collection

This agreement covered a study that was conducted by the National Security Labs on the part of the OFA Team. The study collected information on the best of industrial technologies ("COTS") that had potential to serve classified needs of defense, intelligence, and justice (counter-terrorism).

Policy Initiatives

Summary

Policy initiatives involved a total of 30 agreements and $882M during the course of the game. Fourteen of these agreements documented Congressional actions (e.g., laws), ten were Toolkit options, three were non-probabilistic "studies," and the remaining three were post-Toolkit funded agreements. Some level of policy interest was exhibited by all teams, although Congress was by far the most dominant player in this area, having participated in 45% of these agreements (primarily through the laws). All of these agreements were categorized into one of ten different policy areas, and are graphically illustrated in importance (agreement count) in Figure 13. (Some agreements had multiple parts that were categorized separately.) As can be seen from this figure, there were three policy areas that received considerably more attention than any other: R&D tax credits; lab governance; and lab budget. As outlined in Table 11, these three areas represent 60% of the policy agreements and 65% of the funding.

The agreements in the area of R&D tax credits illustrated that there was a strong consensus that they are important and should be made permanent (P30, P30A, P46, P48, L1b, L10a). There was, however, a strong divergence in the amount of the credit to be given (ranging from 10% to 100%), and what type of R&D work should receive credit (all R&D, all collaborative R&D between industry and federal labs or universities, or all industrial R&D outsourced to federal labs or universities).

Agreements related to governance issues covered a broad spectrum of issues: consolidation and closure (L12, L13); restructuring (L3); creation of a system of labs (P4); formation of Fraunhofer-like institutes (N25); and authorization to conduct certain types of foreign R&D (P47).

Lab budget-related agreements that were successful and remained in force to the end of the game only included a Congressional action that reduced federal lab R&D by 10% (L10b), and a change in DOE policy that promoted partnering by eliminating funds-in taxes and allowing incremental cost recovery (S3). Two unfunded or unsuccessful agreements were related to S&T labs funding (P43, S4). The remaining two agreements dealt with federal labs outsourcing R&D work to industry that initially passed, but was then repealed before it had any effect on funding (P45, L1a).

Policy Perspectives

Tax Law Revisions and Miscellaneous Budget Resolutions

Policy agreements in the area of tax laws or other US government budget issues were primarily focused on

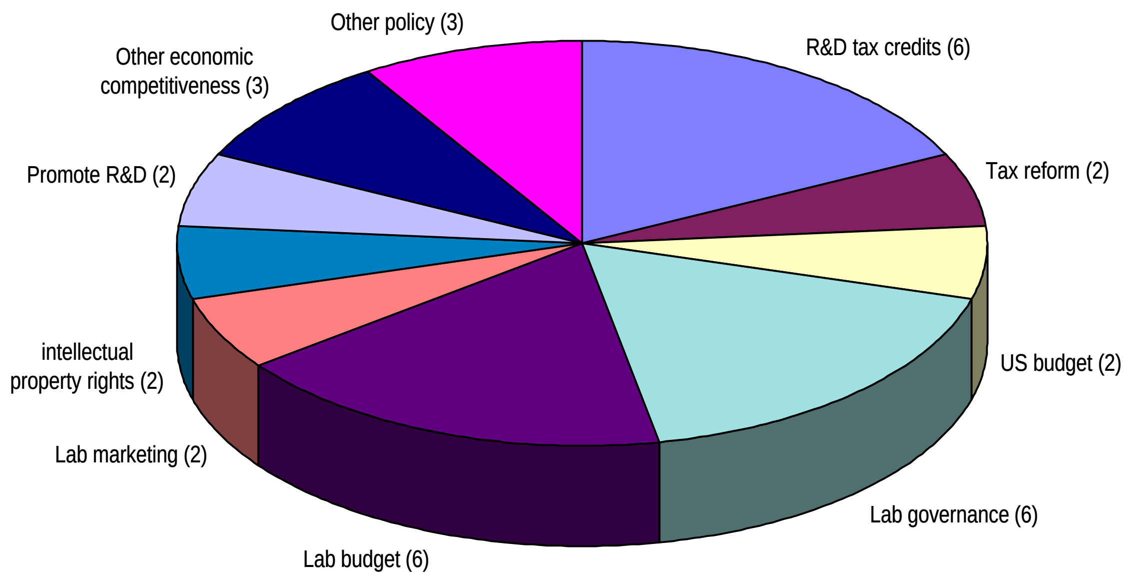

Figure 13. Policy areas.

the issue of R&D tax credits. These agreements are shown in a roadmap format in Figure 14, with investment details provided in Table 12. As can be seen from these data, the issue of R&D tax credits captured the attention of more teams and resources than any other single policy issue. Although there were differences in the details of the credit as envisioned by the different teams, it is the strength of interest in the topic that should be noted. Only the OFA Team and Foreign Countries Team did not show any interest in R&D Tax credits. The tax laws that passed, along with the Entitlement Control Act, were explicitly programmed into the distribution of game funds, and had as much effect on changes in available R&D resources as return on investment. (Further details are presented in Appendix D of this report.)

Table 11. Primary policy investment areas.

	Total invested ($M)	*No. of agreements*	*No. of teams*
R&D tax credits	364	6	9
Lab governance	40	6	5
Lab budget	170	6	5

P30/P30A. R&D Tax Credit

The R&D tax credit is made permanent by Congress and joint industry-national laboratory and/or university efforts are included as eligible for the credit. P30A was a no-cost agreement written by the E/E Team that modified the original Toolkit description to explicitly define the credit to be 10%.

P46. 25% Collaborative R&D Tax Credit

The R&D tax credit is made permanent by Congress at a rate of 25% for joint industry-national laboratory and/or university efforts. All partnerships are required to be formally traceable.

P48. 100% Outsourced R&D Tax Credit

A 100% tax credit for industry is made permanent by Congress for all R&D they fund at national laboratories or universities. This bill also contained

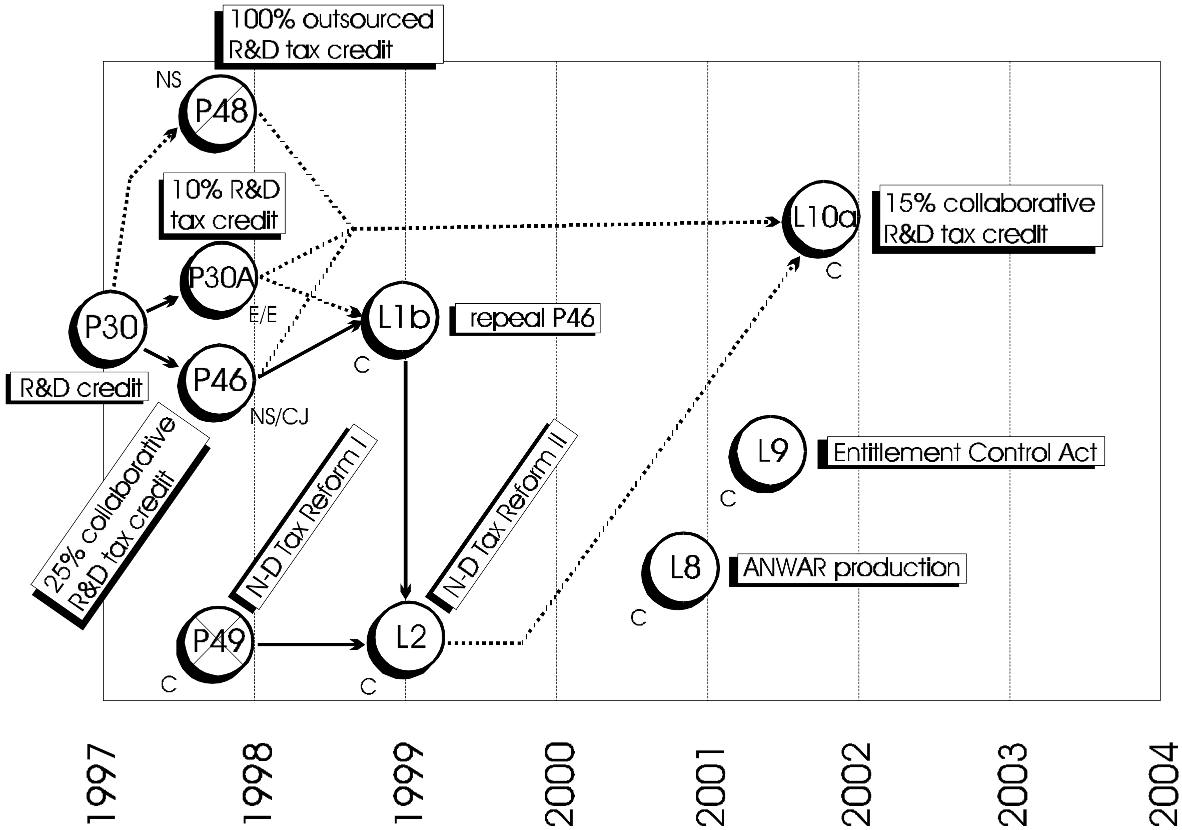

Figure 14. US tax and budget laws roadmap.

provisions to eliminate most of the bureaucracy associated with such funding paths.

P49/L2. Nunn-Domenici (N-D) Tax Reform

This law dismantled the IRS and replaced the income tax with a consumption-based tax. As written, a progressive tax structure was envisioned that would protect those in lower income brackets. It was expected that this radical change would, among other things, encourage investment and lower interest rates. Provisions in the tax law were retained that allowed corporations to rapidly write off capital investments and to enhance R&D tax credits. $100M of the $200M total earmarked for support of P49 was from the Control Team, as noted in Table 12.

Table 12. Toolkit investments in tax laws.

Option number	*50% probability*	*Congress*	*IT/AMfg*	*E/E*	*LS/AMat*	*NS/CJ*	*DOE*	*OFA*	*Universities*	*NS Labs*	*S&T Labs*	*Foreign*	*Total invested*
P30	50		50	50	40								140
P46	100				30	135			35		10		210
P48	20						10			4			14
P49	450	100											[200]

L1b. Repeal of P46

This was a formal repeal of existing R&D tax credit laws in support of implementation of the Nunn-Domenici Tax Reform bill.

L10a. 15% Collaborative R&D Tax Credit

R&D tax credit provisions of the N-D Tax Reform are further enhanced by Congress to provide a credit rate of 15% for joint industry-national laboratory and/or university efforts.

L8. ANWAR Oil Production

As much as nine billion barrels of crude oil may be present within the Arctic National Wildlife Refuge (ANWAR). The field is opened for oil production under the provisions of this law. A conservative $2 billion in revenues for the US Treasury is expected to be raised as a result. Availability of the ANWAR field will also promote US energy security.

L9. Entitlement Control Act

The Entitlement Control Act was a law with provisions to phase down the growth rate in Medicare to 3% over a five year period. At that time, a Presidential Commission will make further recommendations for the Medicare growth rate. The law also had a provision to establish a CPI Commission that would be responsible for calculating and establishing an official CPI [Consumer Price Index] that entitlement growth would be linked to. It was estimated that this would result in a reduction of the CPI by one point. Congress intended to create R&D investment dollars with the "savings" resulting from this Act. These R&D investments would be made in national initiatives rather than explicitly redirecting the funds to support traditional R&D organizations.

Policies Related Primarily to the US Department of Energy

Although they attracted little interest or interaction on the part of industry, policies related to the governance, budget, and marketing of the federal labs, and the DOE labs in particular, had more total agreements than any other policy area. However, as can be seen from Figure 15, there was little connectivity between these different agreements. Table 13 also points out that little in the way of dollar resources were expended in this area.

P4. System of Labs

DOE authorizes the creation of a "System of Labs." The labs and DOE develop and implement the concept.

P43. S&T Labs Funding

This agreement, if it had been successful, would have maintained the fundamental science and technology (S&T) investment in the DOE Civilian S&T Labs at the present level of $1.5B per year. This effort would have included the necessary funding for research, major user facilities, and university partnerships required to maintain the current level of effort. It is interesting to note that the authors of this agreement, the S&T Labs Team, did not invest in it at any level.

P45/L1a. Federal Labs Outsource 25% of R&D

This Toolkit option, drafted by the NS/CJ Team, required all federal labs ("DOE, DOD, DOC") to spend not less than 25% of their R&D budget with the private sector. Matching funds and mission relevance were "strings" placed on these funds, which requirements were never met by any of the industry teams. This option (P45) was quickly repealed by the Congressional Team (L1a).

P47. DOE-Foreign Joint R&D

Under this agreement, Congress would have authorized DOE to work together with foreign countries, labs and universities to conduct coordinated research on global environmental and educational problems. (This Toolkit option was a revision of the original P39. The change was the insertion of the phrase "and educational" into the end of the description.)

L3. Restructure DOE

This law enacted by Congress required DOE to develop a plan for eliminating unnecessary redundancy among its labs and to define core missions for all civilian research labs.

L10b. Federal Labs Spending Reduction

A temporary Science Department was created by this provision of Congressional law. The department's charter was to reduce redundancies in work across the entire federal lab system (including DOE NS and S&T Labs) in order to achieve a 10% reduction in spending without sacrificing technical output.

L12. Lab Consolidation and Closure

Congress authorized formation of a Lab Consolidation and Closure Commission under the same terms and conditions as the BRAC (Base Realignment and Closure) Commission. The commission's charter included purview of all federal

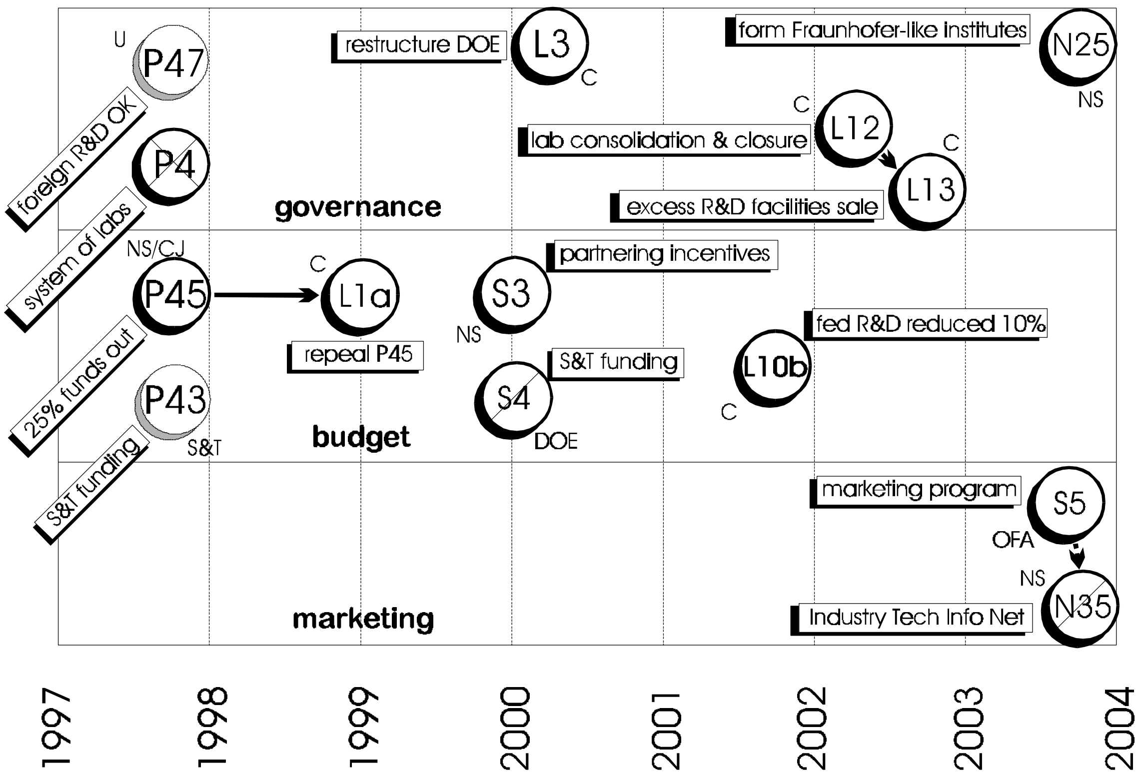

Figure 15. Roadmap illustrating DOE related policies.

labs. Final recommendations from the commission were to be completed by January 1, 2003.

L13. Excess Facilities Sales Enablement Act

This Act was passed by Congress to set up an efficient means of selling excess federal R&D facilities.

Table 13. Summary of DOE-related policy agreements requiring funds.

Option number	50% probability ($)	Congress	IT/AMfg	E/E	LS/AMat	NS/CJ	DOE	OFA	Universities	NS Labs	S&T Labs	Foreign	Total invested ($)
P4	100						10						10
P43	100												0
P45	100					165	5						170
P47	150												0
S4	0						[9]						0
S5	0							5		5	5		15
N25	10								5	20		5	30
N35	10		5							8	5		18

S3. DOE Labs Partnering Support

Under the terms of this no-cost agreement, DOE agreed to eliminate overhead charges associated with partnerships formed with industry, universities, and other federal laboratories. DOE further agreed to allow incremental rather than full cost recovery. Both of these decisions were felt to be critical toward promoting partnerships.

S4. S&T Labs Supplemental Funding

The DOE undertook measures to provide the Civilian S&T Labs with an additional $9M that was to be used in a study to identify and possibly perform preliminary research in R&D areas of importance to the Energy and Environment Industry. Explicit areas to be included in the study were: deep water fossil fuel exploration; portable energy sources; enhanced in-situ remediation; improved fossil-fueled power plant efficiency; advanced nuclear cycles; and special high-temperature materials.

Oversight of the effort was to be provided by DOE and an advisory committee. This agreement is considered to have been unsuccessful because it was never formally accepted by the S&T Labs Team (agreement only signed by DOE). The $9M originally allocated by DOE to this agreement was presumably used for some other agreement.

S5. Federal Lab System Marketing

Under the terms of this agreement, a marketing program was initiated that would promote the capabilities of the federal labs to customers and potential customers, and to help the labs to better understand customer's needs. This program would also aggressively promote lab successes as a means of building public and Congressional support. All labs would coordinate their marketing communication efforts within this program in order to gain maximum impact.

N25. Establish Fraunhofer-like Institutes

Under the terms of this successful agreement, appropriate national laboratories and universities would collectively form a suite of Fraunhofer-like institutes. Each institute would focus on specific technologies and markets within their particular field of expertise. Examples might include photolithography and genome technology.

N35. Industry Technical Information Network

This agreement would have used computing and networking technology to form a single point of contact for information and marketing for the [federal] lab system. State-of-the-art information technology would be used to assure secure, proprietary information management. It was also envisioned that lead labs would be formed for the different technical areas. Presumably this agreement was to be an extension of the previous marketing efforts (S5).

Policies Related to US Economic Competitiveness

Essentially all of the work in the area of economic competitiveness was carried out by the Congressional Team. Work in this area was driven by one of the four original goals established by this team: "To ensure that the United States is globally competitive." A timeline and simple description of this work is provided in Figure 16. No funds were involved in these agreements.

P44/L11. Trade Initiatives

The initial draft of these trade initiatives (P44) placed a pre-condition on all international agreements (including those agreements concluded among private commercial entities) that: all parties were to honor all intellectual property rights; all parties would have parity in tariffs; and terms would include strong dispute settlement at the WTO and through bilateral actions. As finally enacted, the law (L11) only provided for the withdrawal of intellectual property rights in the US to residents of any other country that failed to adequately protect US intellectual property rights.

L4. Critical Industry Preservation Act

Over concerns that increasing foreign competition would cause certain strategically important US companies to lose important capabilities (defined as a critical industry), Congress passed the Critical Industry Preservation Act (CIPA). Under this Act, Congress resolved to provide appropriate contracts and funding to critical industries in order to maintain their capabilities on US soil, regardless of the availability and pricing of similar services or products from foreign concerns. This Act also had provisions to limit foreign access to manufacturing rights and technologies in areas designated as critical. The original issue that eventually resulted in this law was reportedly raised by the OFA Team with the Congressional Team.

L5. American Economic Competitiveness Act

This Act of Congress replaced the Department of Commerce with the Department of Economic Security, and merged it with the US Trade Representative (USTR), International Trade Administration (ITA), National Telecommunications and Information Administration (NTIA), Export-Import (Ex-Im) Bank of the United States, Bureau of Export Administration (BXA), Department of Education, Economic Development Administration (EDA), the commercial and arms sections of the

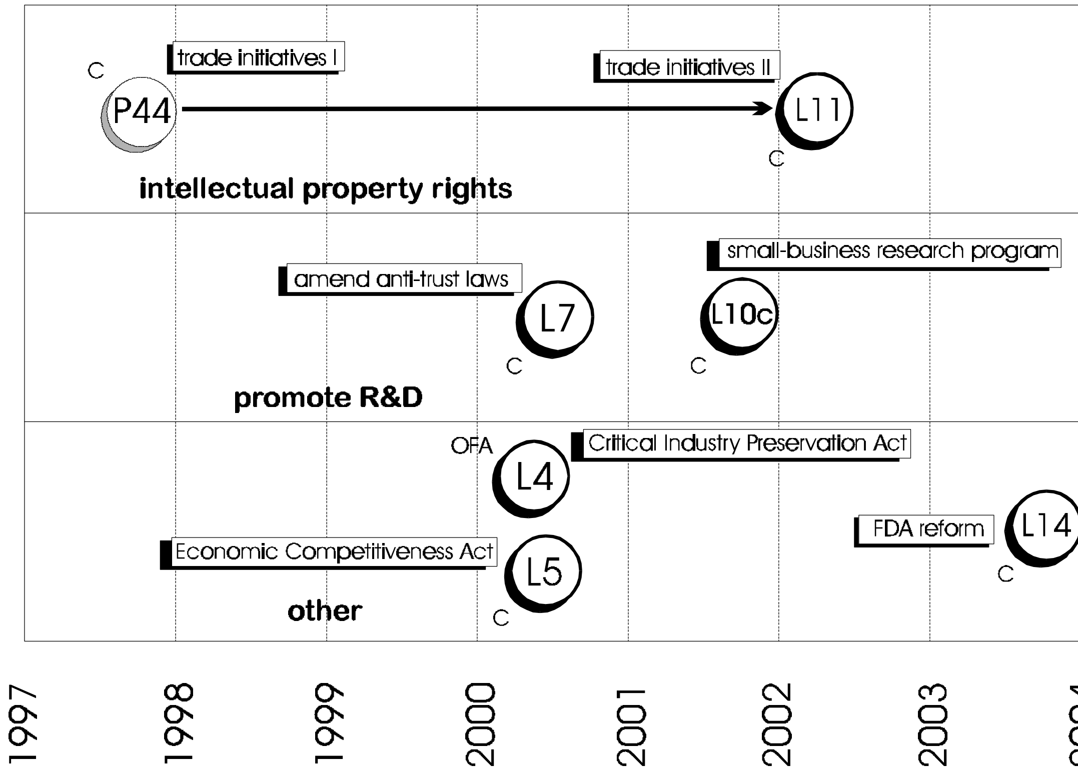

Figure 16. Congressional actions related to economic competitiveness.

Department of State, and the DPIC [sic]. This new department is responsible for coordinating all US economic development. The enhanced coordination, in turn, is expected to provide American economic security through US trade growth, technology exchange, and US technology promotion. In a related move, the National Oceanic and Atmospheric Administration (NOAA) and National Institute of Standards and Technology (NIST) are combined into a single Subcabinet Administration.

L7. Corporate Teaming Act

The Corporate Teaming Act amended anti-trust laws to permit coordination, joint research, and technology cooperation between US firms in industries designated as Critical Technology Research Sectors by the Department of Economic Security.

L10c. Small Business Research Program

This provision of Congressional Law increased the funding to the "Small Business Innovative Research Program." This was one measure (see also L10a and L10b) taken by Congress to promote continuation of critical science, technology, and industrial bases to protect against "surprises" from foreign governments, improve the trade balance, and improve the quality of life for all Americans.

L14. FDA Reform

This law streamlined the FDA bureaucratic approval process by setting up multiple regulatory approval channels. Other provisions of this law included: FDA to be supported by user fees; and removal of regulatory bars to international sales of products not approved by US regulatory agencies if they have been approved by foreign regulatory agencies.

Other Policy Agreements

The following policy agreements did not fit well within one of the other three policy sections, and are so collected here. Although they do not have strong links with other policy issues, L6 and N14 do have links with technology agreements, as noted.

L6. Anti-terrorism Act

This law, passed by Congress and signed by the President ca. 2000, was a joint program geared toward combating terrorism in the U.S. that involved the FBI, CIA, NSA, etc. This law also included a requirement to involve the National Laboratories, and may be considered as enabling of agreement N12 (see p. 24).

N14. Global Village Program

This Universities Team agreement initiated an educational program that utilized the technologies developed under the T5 (virtual work environments) and N4 (technology for education) agreements (see p. 16). The primary focus of this agreement was to create programs ca. 2002 that would enhance global leadership and preparedness for undergraduate students nationwide. Program requirements would include two languages, multi-cultural negotiations, industrial internships, and cultural visits. Students would be part of global project groups. This agreement had a 50% success investment requirement of $40M, and was funded at a level of $75M. Funding was received from the IT/AMfg ($20M), OFA ($15M), Universities ($20M), and Foreign ($20M) Teams.

S2. NS/CJ – NS Labs allocation agreement

This document, initiated by the NS Labs Team, was used to formalize an agreement that the NS/CJ team would invest $20M in toolkit option P15. However, in final form it included an escape clause that was exercised by the NS/CJ Team that allowed its money to be redirected to P45 and P46 if they were “not sufficiently supported.”

Technology Investments Assessment from a Team Perspective

Analysis of technology investments by team is useful in identifying key R&D concerns, especially if players use the opportunity afforded in a game to work outside of their normal paradigm. In addition, it provides a supplemental assessment of team dynamics to that provided by the standard entry and exit questionnaires and evaluations.

General Observations

Forty-eight technology R&D agreements and eleven non-R&D agreements (e.g., policy) received funding during the game. The size distribution for these agreements is provided in Figure 17. Investments closely followed a normal distribution, with a median investment of $105M. (This does reflect positively on the reasonableness and methods used in pricing agreements – although absolute dollars may have been approximate, given a set of R&D projects, a range in project costs would be expected; any unintentional biases in costs would have shown up as a bi- or multi-modal distribution.) In addition to these fifty-nine agreements, five study agreements (no assigned risk) and fourteen Congressional-action agreements (i.e., laws) were executed (total of 78 agreements played). An additional six agreements were drafted and approved but not played (i.e., no money invested). Of the agreements executed, 58% involved R&D investments that consumed 87% of the resources; the majority of the non-R&D investment agreements dealt with Congressional actions that did not require money.

The number of partners in each agreement exhibited reasonably smooth distributions, as shown inFigure 18. Note the big shift toward more partners following the Toolkit session (median number of partners went from 1 to 3). If partnering is evaluated

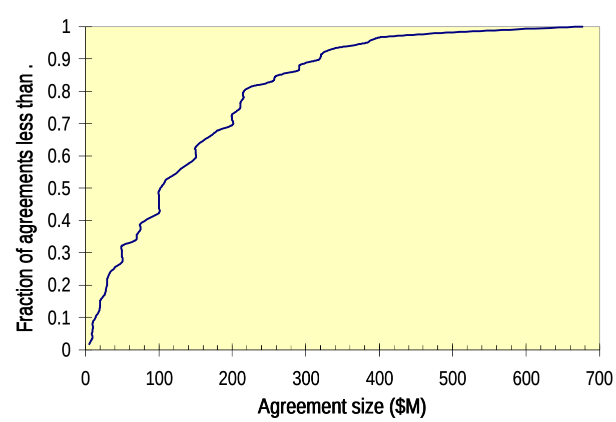

Figure 17. Funded-agreements investment distribution.

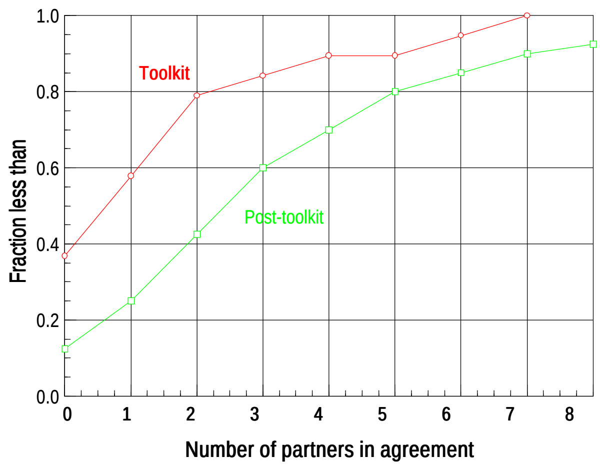

Figure 18. Funded-agreements partnering trends.

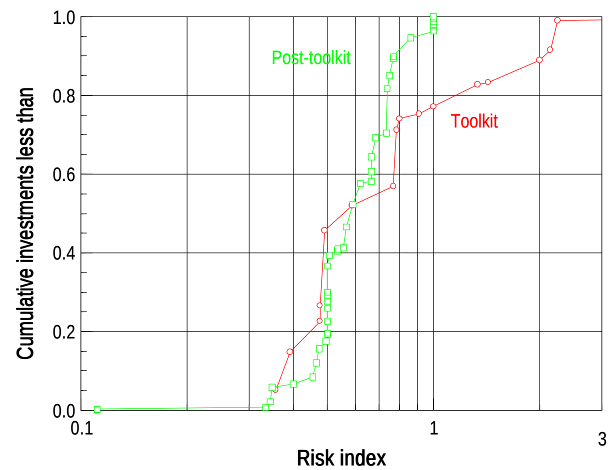

Figure 19. Funded-agreements risk trends.

on a normalized team-by-team basis (see Appendix D), all teams behaved in very much the same way (e.g., similar deviations and medians; average median of 4.4), except for the National Security and Criminal Justice Industry Team that had a considerably higher median (7), and the DOE Team with a lower than average median (2.5).

One possible reason for the overall shift in number of partners would be that the teams took measures to reduce investment risks. To illustrate this, consider the definition of a *risk index* as the ratio of the 50% success probability value to the number of dollars invested in an agreement (increased risk gives an increased index). Investment distributions for the Toolkit and post-Toolkit sessions have been plotted in Figure 19 on the basis of this index. The high-risk "tail" exhibited during the Toolkit session was "lopped off" in later sessions; otherwise the trends are similar. The far end of this "tail" originated when several teams placed very small investments on Toolkit items at a level with no probability of success (funding below the "25% probability-of-success level" was, by definition in the game rules, unsuccessful), perhaps thinking that additional funds were going to be raised before the Toolkit submission deadline. Some teams had made Toolkit investments under the belief that other teams had agreed to provide funding, but they were left without recourse when the other teams pulled out at the last instant (no formal, written agreement in place). Other than this tail, smoothed trend lines for the two data sets are remarkably similar. With a median risk value of 0.5 (Toolkit calculated median is 0.9, but a smoothed trend line gives a median near 0.5 as well), these data suggest that most teams did not like the risk associated with a 50% probability or less, and tended to double the amount of money spent. Perhaps this investment behavior reflects subconscious thinking that doubling the money required for a 50% chance for success would give them a sure thing.

Differences in methods and details of planning were exhibited by the teams. Some teams were oriented toward policies and business plans. Others were very detailed in the specific technologies they wanted to pursue. Some teams developed their technology goals and strategies during the planning session. Others allowed details of their strategy to develop during game play, either due to initial uncertainties or to an adaptive stance. All teams exhibited some level of strategizing beyond a *Carpe Diem* approach. Four teams (Congress, National Security Laboratories, National Security & Criminal Justice Industries, and Information Technology & Advanced Manufacturing Industries) exhibited planning that was interpreted to include a *Crescit Eundo* approach. No team documented any *Impetus Futuro* strategies. In summary, an estimated 55% of the R&D funds were spent in a *Carpe Diem* fashion, 37% were spent on what was interpreted to be *Partes Pro Toto* planning, and the remaining 8% exhibited characteristics of *Crescit Eundo* strategies.

In evaluating team agreements, it was also of interest to learn if any particular focus was exhibited by the teams, as compared to expected (i.e., historical) interests. From an R&D perspective, it turned out that there was emphasis on information technologies (IT) by seven of the ten US teams. Among them, $500M above their expected contributions of $300M ($800M total) was invested in IT. This $500M excess diverted to IT represented 7% of the total game R&D expenditures. However, the fact that the majority of the US teams exhibited a strong interest in IT indicates the impact this field is having nationally. It may also signify that there is broad-based recognition of the need for an increase in the R&D efforts in the IT field. Of the other three US teams, the IT/AM team spent $460M (26%) in non-IT/AM agreements; the remaining two were the NS/CJ Industries Team and the Civilian S&T Laboratories Team, whose IT investments were in keeping with their expected paradigms. Thus, in an overall game context, the US teams participated in approximate proportions to what is observed in real life (the shift in IT/AM team funds having compensated for the other team's IT expenditures). Other, non-IT allocations displayed no strong overall trends. In contrast to the general US team's behavior, the foreign team under-spent IT/AM investments by $500M, instead choosing to focus on US energy R&D programs (which historically has had essentially no foreign interest on the level of the monetary scales discussed here). The net effect of this shift in team focus was to cause the net game funds to shift **from** IT/AMfg to energy and environmental agreements (see Figure 20).

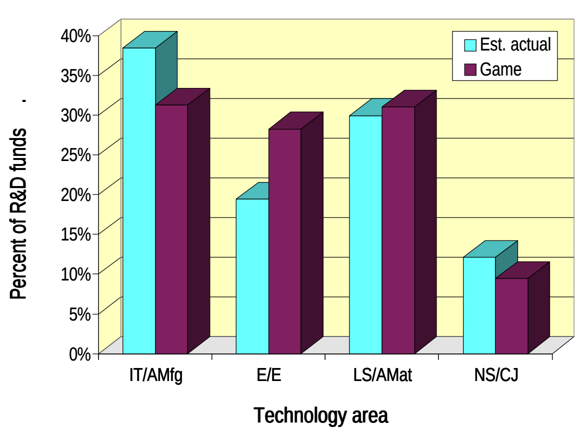

Figure 20. Total game R&D spending by technology area.

From a policy standpoint, the most significant efforts during the game were on agreements related to taxes, with a bent toward offering incentives to industry to invest in R&D. Twenty-eight percent of the policy agreements were related to this issue, and every team except the OFA and Foreign teams invested part of their resources in support of one or more of these agreements (Toolkit options).

Although it may have escaped many players during the game, the policies approved and implemented, primarily on the part of Congress, had a measurable effect on the distribution of funds. This can best be seen in Figure 21, where tax laws and changes in entitlements are reflected in increased industry R&D funds and decreased federal ("non-industry") funds (numbers reflect percent change over pre-play baseline funding plans). Total R&D funds in the game also increased slightly as a result of these changes. For comparison purposes, the effects of external events on the amount of money in play (as percent of pre-play baseline) and the return on investment (ROI) for R&D (as a percent of R&D investments) is also shown. It is interesting to note that while some teams like industry were heavily focused on maximizing their ROI, the oft ignored Congressional play had a larger impact on the total funds they received to play with! Also worthy of mention are the external events. Although many teams tended to ignore these events, only the interplay of the Congressional and Foreign teams managed to keep the specter of war from having a pre-planned, major influence on game resources. A second, pre-planned major disaster involving

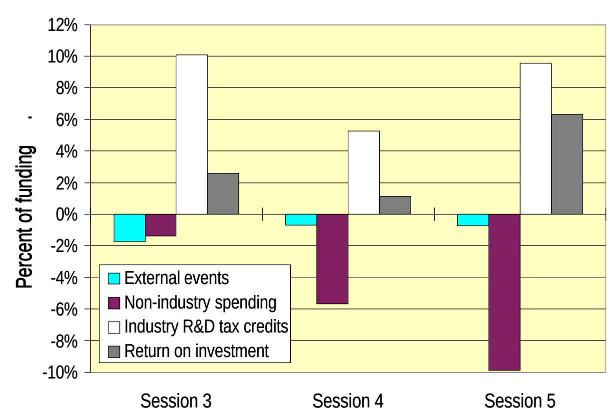

Figure 21. Baseline funding changes.

computer crime was also unknowingly diverted by the heavy R&D investments in computing information surety.

During the conduct of the game, three other teams strongly influenced the play: the Energy and Environment Industries; the National Security Laboratories; and the Information Technology and Advanced Manufacturing Industries. These three teams originated 55% of all new R&D agreements and controlled 58% of all the out-of-team funds raised ("other peoples money"). On the basis of total expenditures (raised and own funds), these three teams influenced how 63% of the game's R&D funds were spent. For reference, the original resources allocated to these three teams only amounted to 37% of the total available funds.

R&D Summit Meeting

An R&D Summit meeting was held early on the third day of the Prosperity Game. The summit consisted of a panel of players, one from each team, who were to answer questions from the perspective of their teams. The questions were selected prior to the Summit using feedback from the game staff on the most important issues and perceptions they had observed. The questions and answers (based on a reconstruction from staff notes) are given here.

Question 1: Some people have called the National Laboratories the "Crown Jewels of R&D." However, based on polls we've conducted over the last 5 years (i.e., opinions expressed in yesterday's sessions), we have found that industry questions the labs' relevance and importance. Are the labs important contributors to industry R&D? If so, how can industry perceptions be changed? How can partnerships be encouraged? Who needs to do what?

Carl Poppe (U): An important product of universities is basic research. Industry has to forego and focus on short-time turnaround. The future will be dependent on basic research. National labs form an important part of the basic infrastructure. National labs are large, individual units, universities are centralizing agents; a triple partnership with industry should be formed.

Pete Lyons (NS Labs): Priority—maintaining national security requirements should be the focus of the labs. There are many examples other than national security—real-life examples in long-term, multi-disciplinary areas, including interests in reliability from the perspective of/for industrial interests. Laboratories should not be viewed as a source of dollars, but of vast technology. How do you put value on the 'value' of technology? How do we encourage more partnerships? The 25% flat-tax credit, and T45 and T46 Toolkit Options helped to build partnerships.

Bill Bottoms (IT&AM): Every effort should be made for dual-use, but the mission should not be expanded. Long-range R&D investment is determined by Congress and the President. Industry is willing to help, but the current tax policy precludes this. I would like to see more long-range investment in R&D.

Bob Hirsch (E/E): I have been associated with the labs for decades; they are outstanding in terms of basic research, but in terms of applied research the record gets spotty and variable. The record for development activities is variable; part of the reason for that is that the labs grew up in an isolated environment and have not traditionally had close relationships with industry. In recent years, closer relationships began to develop. I have seen some excellent relationships in some areas, in other cases lab people have no idea what industry wants. Recently, Congress is beginning to question CRADAs and "corporate welfare"—taxpayers must get payback for their dollars. Converse: the way things worked for decades was that results were published, which effectively gave US taxpayer-paid results to foreigners to exploit. Foreign scientists came into the labs and picked up information directly. Now we recognize we are in a globally competitive world. I don't suggest we stop publishing, but we have a serious problem that requires attention. I think the labs are in the process of changing—there needs to be clarity of mission, but that is complicated. I think there is a bright future for the labs.

Bill Studeman (NS&CJ): I think that government, industry and the labs should converge. A strategy is needed that creates outcomes. Incentivize. Industry is doing less R&D. I think it is important to find ways for the labs and government sponsors to play an important role in R&D that will continue to be of great interest in the future. There are too many labs, too much redundancy, too bureaucratic; efficiencies have to be looked at.

Jim Williams (OFA): We have to pay attention to long-term national well-being—not the 'immediate' good life. The world is not a benign place. We cannot exist without the core competencies of the national laboratories; we need those capabilities within the national lab system. I believe, as do others in the intelligence community, that the national laboratories must be incorporated better into the Federal research and development effort in support of certain select programs. All of the intelligence agencies have been reduced in size and have lost significant expertise, especially in the field of scientific and technical analysis. The continued unsettled conditions around the world mandate that the nation retain a capability to collect and analyze information pertaining to weapons of mass destruction, which requires expertise in delivery systems, propulsion, materials characteristics, testing facilities, production installations, weapons characteristics, etc. As part of their unique beginnings, the national laboratories are capable of doing this, and they are the only remaining centers of excellence to which we can turn. They have a proven track record supporting all of the intelligence agencies and have been superb at both quick responses and development of specialized items requiring that only one or two be constructed. Unfortunately, their services have been and still are funded as though they are contractors, and contract moneys are among the first to be cut in times of fiscal reductions. I believe that at least Los Alamos, Livermore, and Sandia should be designated as "National Centers of Excellence" and receive some funding through the National Foreign Intelligence Program as a means of assuring that the United States has available experts who are nationally recognized.

Beverly Hartline (S&T Labs): Science and Technology Labs have formed a system and are working to eliminate barriers to partnerships. We have a concern about national infrastructure and capability in basic research, related to the modernization of the set of major national user facilities we operate for the nation. No work has been done since the early 90s to develop new facilities or upgrade older ones, so we are losing world leadership here. We are interested in collecting requirements for future major research facilities that serve the broadest possible spectrum of needs, and are too costly to proceed without multiple partners. We also want to interface more effectively with industry, so that our unique expertise can be tapped where it can best benefit industry. One mechanism is through enhanced and increased personnel exchanges, and we commit to sending people to work with the industry groups here, to understand their perspectives and what is needed.

Doug Comer (C): We have been engaged in bold initiatives and have had great results. One thing we noticed yesterday—that our popularity increased because Congress had money to spend. How can we ensure taxpayers are getting best value for $. The issue for us is aggregate investment in R&D. Does it matter if investment comes from industry, government, etc.? The labs are now defining their role for the future. I support maintaining the lab infrastructure, but support will only be as strong and continuous as they demonstrate return to the public sector. Partnering is a critical issue— transferring technology from the labs to the private sector.

Sam Bonanno (LS&AM): Part of the problem is that the labs are important, but not as important as they could be. Their mission is a bit ambiguous. What is their mission now? Transferring technologies to industry, etc.? There must be a set policy that everyone understands, greater communication, marketing of lab technologies, sense of urgency; I feel a lot of the lab technologies are beyond practical application at this time. Partnerships should be a major mission; there should be a transfer and cross-pollination of personnel. I feel there is redundancy in several labs; optimize and eliminate duplication. Commercialization of technology should be demonstrated; Congress sent mixed messages—this should be clearly defined.

Vic Berniklau (DOE): Can labs be important to industry? Are they currently important to industry R&D? There are very different sets of cultures in industry and the labs (particularly regarding performance, cost, and schedule parameters). There are pockets of extreme cooperation, e.g., user facilities. Other pockets exhibit past laboratory arrogance and a desire to return to the "good old days." As a result, the labs are not monoliths. Why are things not changing faster? Incentives are needed. You can't expect change without drivers. There will be change if sufficient incentives are offered—from Congress, labs, and specifically management. What can we do? First, take a look at our customer orientation. Who is the customer? What does the customer want? There is a general absence of that concept in many quarters of DOE, labs, and even industry. Look at specific needs in performance, schedule, and cost parameters. Take a more intense look at customer needs while keeping focused on the mission. In addition, we need to move available lab technology into the private sector. To accomplish this, we need more partnerships, which is the primary tool for this translation. The logo of the DOE game team includes three overlapping circles of Energy, National Security, and Environment, with Science and Technology in the common overlap of the three circles; but the major point for this game is the theme of the logo "Partnerships for Sustainability & Competitive Advantage."

Gene Lussier (F): Consideration should be given to having two foreign teams—one to represent developed nations and the other to represent emerging nations. Another option would be one team with two parts. Foreign countries look to the labs to preserve the nuclear arsenal of the world. We see certain opportunities in selling technologies, but not discarded technologies. Foreign countries are bringing vast markets to the US, but are seeing them somewhat ignored. Foreign countries will work together if ignored, or if significant road blocks are implemented by the US. A good partnership works both ways—some feel we are giving up too much.

Bob Hirsch (E/E): Regarding customers - the situation is complicated. Is the customer DOE, Congress, scientific community, or industry? This aspect needs clarification.

Question 2: The nation needs an improved Technology Delivery System. What are the desired characteristics and roles of this new system? What metrics would you recommend to measure progress and resource allocation?

Pete Lyons (NS Labs): We found ourselves moving in a realistic direction. The national labs try to serve as the catalyst for ASCI—primarily of national security interest. We are trying to structure a national technology delivery system. We set as one of our goals to work toward a system of labs and to come up with an integrated information system. We looked at ways this system is exercised—number of contributing partners, etc.

Bill Bottoms (IT&AM): The real metric—how quickly can we move technology into the economy, relative to the pace by international competition. I believe that the President and Congress hold keys to helping us to be more effective (depreciation, regulation). Our health care system has to start new product delivery in Europe. We need to move products into marketplace more quickly in the US.

Carl Poppe (U): The University group looked at the role of universities—we must have 21st Century universities. They must provide a future work force that can take their place in the world. We need to focus on education K through 12, as well as higher education.

Gene Lussier (F): One problem for the foreign team is impediments we run into legislatively trying to become a part of the process. Market focus will drive technology delivery and development, not the other way around. The technology developers must identify their own user (buyer, customer) community and become comfortable with a variety of users to compete. I believe the major metric for some time will continue to be budget support.

Vic Berniklau (DOE): Is industrial partnering really a mission? Since we are going to have difficulty getting a singular view, we should get started with an overall direction. The basis for this is Marketing, which is a "verboten" word in some quarters, but it is something we do every single day, i.e., finding out what someone (e.g., a customer) wants and convincing them of what we think they should do. This could include telling industry what the specific labs are doing as well as their capabilities. The DOE lacks this type of marketing program. The most important metric of success continues to be customer satisfaction.

Sam Bonanno (LS&AM): Metrics to measure progress and resource allocation are needed—$ spent by industry and labs, number of people affected by initiatives, quality of life, etc.

Doug Comer (C): Congress is struggling with issues, dealing with vested interests. Congress should work toward a less regulatory environment. Substantive legal reform in this country is needed.

Beverly Hartline (S&T Labs): For improved technology delivery, we need to keep both the human resources pipeline and technology development pipeline full and free of blockages. We need to implement a process to identify and eliminate barriers and blockages continuously. It is very important also to keep the pipeline full. To do this requires that we continue to pursue basic science as the precursor to technology development and delivery in the future. Metrics would be job creation, workforce quality, and workforce productivity.

Jim Williams (OFA): Metrics of the labs are sometimes difficult to visualize by industry because labs are not involved in mass production. Labs can't change the system themselves; they need administration leadership and changes in legislation. The theft of patents and intellectual property impacts everything we do. There is sufficient room for the laboratories to cooperate with industry to make available to society the fruits of research programs supported and funded by the government. Applicable laws will probably have to be amended to define clearly the mission of the laboratory system and the role of the DOE in administering the laboratories. We must exercise care not to release the products of our research into a world of commerce for the ultimate benefit of corporations that are foreign controlled. This requires that the nation pay attention to who owns whom when authorizing the laboratories to enter into various CRADA's. Economic espionage being what it is today, even some of our so-called friends are eager to steal our work so that they can gain a competitive advantage. I am concerned that there is little understanding of the roles to be played by the laboratories, by universities, and by industry in research and development and in commercialization of the outcome. We require some mechanism to make known who is working on what research and to inform industry of what has been born within the laboratory system. At present, it is a 'push' system in which individual laboratories seek potential partners to commercialize individual products or technologies. More collaboration is needed, as is a better system to exchange ideas and keep all parties aware of their colleagues' activities (within the constraints of classification).

Bill Studeman (NS&CJ): An environment of technology cooperation is needed, rather than facing an environment of fundamental tension. Technology proliferation represents both risk and benefit to this country. DoD has less money to put on R&D and must put on leveraged technology. What technologies will proliferate? What are the major technology requirements of the future, dollars to drive, incentives, intellectual property rights, regulatory environment, etc.?

Bob Hirsch (E/E): The tax laws are extremely important. Changes would help to move technology more quickly into the marketplace. Frustration: Industry isn't picking up what the labs are offering. Maybe their "goodies" aren't always so "good." The labs must interact with customers to do marketable R&D.

Question 3: What specifically is being done relative to enhancing the availability of clean, inexpensive sources of energy, especially for transportation?

Bob Hirsch (E/E): We are conscious of the need. There is a very ambitious Partnership for a New Generation of Vehicles (PNGV) in the US aimed at producing up to three times the mileage of present vehicles. Partnership of big three with the government. Government management is not as effective as it could be. If government can't do its part well, there will be a problem in the future.

Bill Studeman (NS&CJ): Energy will be a critical requirement in the 21st century. Two factors are important: the way things are incentivized and the way oil companies operate today—technology. One overriding technology not developed is the *battery*. A soldier today carries more batteries into battle than bullets. We will not advance significantly until a cross between batteries and capacitors can be done by industry and the labs.

Beverly Hartline (S&T Labs): We need to think out-of-the-box on this: can we get whatever results from transportation using other methods, like video conferencing, telecommuting, telepurchasing, etc.? Why move 2000 pounds to transport 200 pounds? That is intrinsically wasteful of energy. We need to think of ways to get the same results with lower use of energy (not transporting people and items, if the goal doesn't require it), as well as improving the availability of environmentally clean, inexpensive, and long-lasting energy sources.

Bill Bottoms (IT&AM): How do we improve efficiency in manufacturing processes, transportation, etc. We need longer range, lower cost and cleaner energy—I believe fusion is one option.

Pete Lyons (NS Labs): There are a number of ways that core competencies can be applied to energy conservation—fuel cell, combustion, energy cell, etc. Key points: Customer—very much heard now, as opposed to 10 years ago; Marketing—still very rarely heard at Los Alamos, not well accepted; Incentives—struggling in interactions with industry. We have seen programs build up and then come crashing down. There needs to be some degree of constancy. Incentives are needed.

Gene Lussier (F): Foreign countries have much to contribute. We have learned much from the roadmap process of many industries. The process has developed as a way of offsetting foreign government mandated planning processes. A roadmap on energy should be created. The labs could be the catalyst for leadership in this country. We should target competitiveness; the rest of the world is somewhat ahead of the US.

Vic Berniklau (DOE): I believe the labs have the technological brilliance to solve almost any problem that is subject to a technical solution They thrive on technological challenge and have proven this many times. But for industrial problems, they must work hand-in-hand with industrial representatives to assure inclusion of industrial concerns, e.g., performance, schedule, and cost parameters. The REAL problem is not technology, but one of VISION and FOCUS. We lack the vision to determine the major problems that the labs could work with industry and the focus of resources on these problems. Instead, we continue passing out diminishing resources for a multitude of existing projects and starving each of them. If we could focus our resources on major issues which have a technological component and challenge the labs, success is almost assured.

Sam Bonanno (LS&AM): The big three would have been hit by anti-trust laws if they had tried in the past to cooperate to design fuel-efficient autos. Are we talking about cheap fuel for transportation, compared to the rest of the world? Is the issue conservation or cost of energy?

Doug Comer (C): The energy cost works out to about 4 cents per mile at the pump for my car. Total cost to own the car is about 10 cents per mile. This country has never been at risk for energy insecurity. Why does energy independence bother us? The real issue is the totality of factors we are striving for. The energy cost for electric cars fails to take into account developmental and environmental costs—e.g., batteries which use toxic metals, etc.

Game Metrics

Six metrics were tracked and updated during the game to simulate the impact of game play on life in the United States. The primary purpose of these metrics was to provide an additional tie to the real world in analyzing the results of the game. The six metrics were:

- Growth in corporate profits (%)
- Growth in GDP/capita (%)
- Federal deficit/GDP (%)

- Trade balance/GDP (%)
- Quality of life (index value)
- Defense preparedness (index value)

The magnitudes of the changes in metrics resulting from game play are not important, nor are they claimed to be accurate. Rather, they are meant to remind us that investments in R&D have a significant impact on the economy, our quality of life, and our standing in the world. Decisions impacting R&D should be made with these things in mind.

Current and forecasted data were used to calculate baseline projections for each of the metrics. These baseline projections are shown as the dashed lines in the figures below. Most of the metrics were not directly measurable in the game context. Thus, correlations were made between these metrics and factors that were directly measurable in the game, and that depended upon the actions of the players. The factors measured in the game were:

- Total spending - by all teams on investments (*note: all game money is R&D money*)
- Labs industry leverage - Industry:Labs dollar ratio on lab team investments
- Corporate tax rate - as mandated by Congress
- R&D vs. Entitlements - reflecting changes made by Congress
- Foreign team leverage - US:Foreign dollar ratio on foreign team investments
- Quality of life - fraction of all agreements impacting security, safety, health, or environment
- Defense spending - government money spent on technology that would impact the battlefield

Table 14 shows how the metrics were derived from the measured factors. The first row of Table 14 gives formulas to calculate each relative factor. The numbers in each of the relative factor formulas were based on either projected fiscal data, or results from the prototype game. A total factor for each metric is then calculated by summing all of the relative factors modified by their respective multipliers, which are given in the bottom half of Table 14. A total factor of greater than one increases the metric relative to the baseline. Two standard deviation numbers are given in Table 14: one for the total factor, and one for the metric. Deviations in the total factors from one were measured in standard deviations; the relative change in each metric was then calculated from its standard deviation.

Table 14. Formulas and multipliers used to calculate metrics.

	Total spending	***Labs industry leverage***	***Corporate tax rate***	***R&D vs. entitlements***	***Foreign team leverage***	***Quality of life***	***Defense spending***	***Gas price differential***	***Standard deviation in factor***	***Standard deviation in metric***
Relative Factor formulas	$ / 1512	# / 5.0	50%/ #	# / 1.0	# / 2.5	# / 0.45	$ / 300	$ / 1.25		
	Relative factor multipliers									
Growth in corporate profits (%)	0.40	0.10	0.25	0.25				-0.06	0.30	1.70%
Growth in GDP/capita (%)	0.40	0.10	0.25	0.25				-0.04	0.30	2.55%
Federal deficit/GDP (%)	0.30	0.10	0.30	0.30				-0.02	0.30	1.30%
Trade balance/GDP (%)					1.00			0.02	0.50	1.25%
Quality of life						1.00		-0.01	0.50	6.00%
Defense preparedness							1.00			

The metric standard deviation for quality of life is for growth in the quality of life index. This growth value is then translated into the appropriate index value for plotting. The defense preparedness index value was calculated as

$$DP = DP_{baseline} / 2 * (1 + RF_{def.\ spending})$$

where RF is the relative factor. The metric standard deviations were based on historical or projected values.

Values for each of the measured factors for game sessions three through five are given in Table 15. These are the values that were used in the formulas given in Table 14 to calculate the impact of game play through metrics. The values for total spending, labs industry leverage, foreign team leverage, quality of life, and defense spending were obtained directly from the investments made in the game. The corporate tax rate was lowered from a game basis of 50% to 45%, and then to 43% as a result of Toolkit investments and actions taken by the Congress team with regard to R&D tax credits. The R&D vs. entitlements value was increased from 1.0 to 1.1 after Congress passed legislation to phase down the growth rate in Medicare to 3% over 5 years to make additional funding available for R&D. The sharp rise in gas price in session 3 was preprogrammed into the game. Actions in the energy area to improve fuel efficiency helped to bring the price of gas back to 1996 levels within two sessions. An example calculation for growth in corporate profits (%) for session 3 follows:

$$Factor = \left(\frac{870}{1512}\right)0.40 + \left(\frac{5.89}{5.0}\right)0.10 + \left(\frac{50\%}{45\%}\right)0.25 + \left(\frac{1.1}{1.0}\right)0.25 - \left(\frac{1.70}{1.25}\right)0.06 = 0.819$$

$$Deviation = \frac{Factor - 1.0}{\sigma_{Factor}} * \sigma_{Metric} = \frac{0.819 - 1.0}{0.3} * 1.70\% = -1.03\%$$

The calculated value for this metric for session 3 is thus 1.03% less than the baseline value. Calculated metric values for sessions 3, 4, and 5 are shown in the years 1999, 2001, and 2003, respectively in subsequent figures. Intermediate years are interpolated.

The metrics of game play are shown in several figures along with their pre-game (baseline) projections. All spending in the game was assumed to be in constant 1996 dollars. Thus, all growth rates are real growth, exclusive of inflation. Figure 22 shows the annual growth rates of both corporate profits and GDP/capita. The baseline growth rates of 2.2% and 1.4%, respectively, are based on projections using the President's 1997 Budget proposal. The corporate profit growth rate was assumed to keep pace with the projected GDP growth rate, while the GDP/capita growth rate accounted for projected population increases. Figure 22 shows that the game play caused decreases in both growth rates for the first two years, with ever larger increases in the growth rates each of the next four years. Most of the fluctuation in growth rates was due to total spending; in session 3 spending

Table 15. Game values for measured factors used to calculate metrics.

	Total spending	*Labs industry leverage*	*Corporate tax rate*	*R&D vs. entitlements*	*Foreign team leverage*	*Quality of life*	*Defense spending*	*Gas price differential*
Session 3 values	870	5.89	45%	1.10	1.73	0.60	163.5	1.70
Session 4 values	1764	8.04	45%	1.10	7.55	0.40	350.8	0.75
Session 5 values	2639	17.20	43%	1.10	3.02	0.74	224.6	0.00

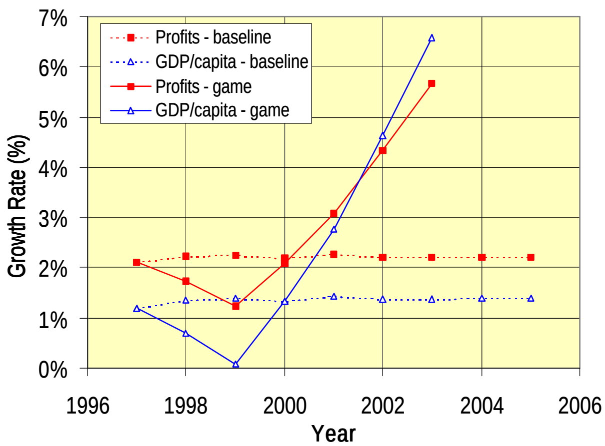

Figure 22. Annual growth rates in corporate profits and GDP/capita.

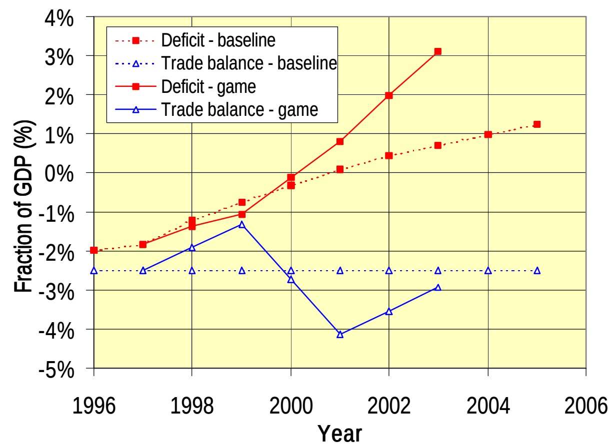

Figure 23. Federal deficit and trade balance as a fraction of GDP.

was much lower than the baseline, while in sessions 4 and 5 the spending was near and well above the baseline, respectively. A very high labs:industry leverage contributed to the high growth rates in session 5, while the changes made by Congress in the corporate tax rate and Medicare spending were positive trends in the growth rates in all three sessions.

The federal deficit and trade balance are shown in Figure 23 as a fraction of GDP along with their projected values. The deficit projection through 2002 is from the President's 1997 Budget, while the trade balance was projected by the game designers to remain constant at 2.5%, close to its 1995 value. Figure 23 shows that in the game, the federal budget was balanced slightly sooner and a budget surplus accumulated faster than projected. This was due to the same factors that caused increases in the corporate profits and GDP/capita growth rates: lower government spending on entitlements and much higher private investment leading to greater tax revenues. The trade balance decreased in session 3 due to less than average leveraging of US money by the foreign team (i.e. less US money left the country). Sessions 4 and 5 saw an increase and then a decrease in the trade balance, again due to more, then less, foreign leveraging of US money.

Figure 24 shows quality of life and defense preparedness using an index value along with their projections values. Quality of life was projected to decrease at the rate of 2% per year due to factors such as perceived decreases in personal safety, economic security, and quality of the environment for the common citizen. Defense preparedness was also projected to decrease due to projected decreases in US defense funding. In the game, quality of life increased (from the baseline value) due to the high fraction of agreements that were felt to positively impact safety, security, health, and the environment. Defense preparedness decreased substantially during session 3 due to a large drop in defense spending, then increased sharply in session 4 due to a large defense outlay on anti-terrorism measures, and then dropped again in session 5.

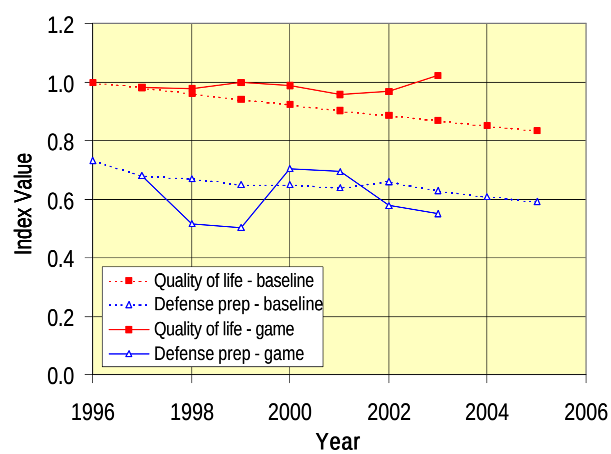

Figure 24. Quality of life and defense preparedness by year.

Follow-on Ideas

The players at this Prosperity Game generated many ideas for follow-on activities aimed at partnerships and promotion of R&D in science and technology. These ideas were gathered primarily through both written feedback from the players and notes made by the game staff. The ideas have been grouped and refined and are presented here.

I. POLICY INITIATIVES

A. LABS/DOE COULD LEAD

1. Marketing

a) IDENTIFY DIFFERENTIATING STRENGTHS AMONG LABS, INDUSTRY, UNIVERSITIES

- What makes the lab(s) different from each other and industry or university R&D centers?
- Promote core competencies, facilities, multi-disciplinary approaches.

b) IMPROVE MARKETING/ ADVERTISING

- Expand market research:
  1. Survey Customers (e.g., Weapons Labs team survey of other teams in PG – “What can we do for you ...”).
  2. Document lab benefits for taxpayers.
- Prosperity Games updates on Sandia Web pages.

c) HELP DEVELOP R&D CHAMPIONS

- Develop and teach a course on the history of US government-funded R&D and the resulting national benefits; estimate returns on investment. Offer course and notes to all interested parties in labs, industry, government, and universities. Seek multiple authorship from different organizations.

2. Cost Reductions

a) REDUCE WFO UP-FRONT COSTS

- Reduce advance funding from 120 to 45 days (can this be further improved?).

b) ELIMINATE DOE TAXES

c) ADOPT BEST BUSINESS PRACTICES

- Use private sector methods to do government work (indirect overhead cost reduction by adoption of industry standards vs. DOE orders for site operations and business practices).

d) PROMOTE STANDARDIZATION

- Make information exchange between labs and industry easy.

e) DEVELOP METRICS

- Effectiveness and return on investment of R&D.
- Optimize investment of federal R&D resources to enhance the “quality of life” in the US

3. Licensing Technology

a) ACTIVELY IDENTIFY LAB TECHNOLOGIES THAT ARE OR COULD BE SUITABLE FOR LICENSING

4. Management

a) IMPROVE THE INTEGRATION AND PARTNERING OF THE DOE DP & ER/EM LABS

b) PRIVATIZE PARTS OF THE LABS TO BETTER ENABLE PARTNERSHIPS WITH INDUSTRY/ UNIVERSITIES

- Find ways to avoid entangling industry funds/needs with federal control/oversight

c) CREATE TEAMING ADVISORY GROUPS

- Develop a charter to reduce barriers among labs, and between labs, industries, and universities.

d) CONTINUE DEVELOPMENT OF THE SYSTEM OF LABS CONCEPT

- Improve coordination/communication, e.g., a virtual-office link between

principals (Internet video/voice/chat/data)
- Partner to solve problems, such as through the use of suites of facilities (e.g., user facilities based on technology areas that cut across lab lines)
- Super-advisory board
- Eliminate interlab backbiting
- Help reduce perception of regionalized labs.

e) BROADEN OUR MISSIONS
- E.g., replace some OFA in-house R&D where appropriate and cost effective

5. Customer Focus

a) ENABLE ACROSS-THE-BOARD, BI-DIRECTIONAL SABBATICALS/PERSONNEL EXCHANGES
- With other labs, agencies, universities, and industry.
- Important for culture (and technical) exchange/networking.

b) DEVELOP AN EASIER MEANS OF PROVIDING INDUSTRY SUPPORT
- "Spot solutions"
- Job shopping and "Kelly" persons services, consulting, etc.

c) MAKE LABS MORE USER FRIENDLY SUCH AS THROUGH THE USE OF GATEKEEPER(S)

d) SUPPORT FULL IMPLEMENTATION OF STANDARD COST/PERFORMANCE/SCHEDULE CONTROL TOOLS

B. INDUSTRY (COUNCIL ON COMPETITIVENESS, LABS INDUSTRY ADVISORY BOARDS, ETC.) COULD LEAD

1. Conduct National R&D Summit

2. Identify And Define Strategic Technologies (US)

- These are technologies that should be federally supported regardless of other R&D.

3. Develop Constituency Of Labs Champions

4. EDUCATE Congress To Implement Bills Supportive Of R&D

- Replace income tax with a consumption-based tax or a flat tax.
- Make R&D tax credits permanent.
- Create tax incentives for partnering with labs.
- Entitlement Control Act – A law to phase down growth rate in Medicare to 3% over 5 years – makes dollars available for R&D.
- American Economic Competitiveness Act – Replace the Dept. of Commerce with the Dept. of Economic Security. Merge USTR, ITA, BXA, Dept. of Education, DPIC, EX-IM Bank, NTIA, EDA, and commercial/arms sections of Dept. of State into one department; NOAA and NIST together into a Sub-cabinet Administration. Intent is to enhance coordinated efforts (including R&D) to secure American economic security, trade growth, and technology exchange and promotion. Include efforts to:
  1. stop massive piracy
  2. gain access to world markets
  3. stabilize currency
  4. provide access to competitive low-cost capital
- Corporate Teaming Act – An amendment to anti-trust laws to permit coordination, joint research, and technology cooperation between US firms in industries designated as Critical Technology Research Sectors by the "Department of Economic Security." Repeal of anti-trust measures in R&D areas that go beyond the traditional violations of anti-trust (e.g., price fixing, coercion & duress, etc.).
- Anti-terrorism Act – National terrorism initiative (joint program) that utilizes the best resources available from FBI, CIA, NSA, labs, etc. (including R&D),

to protect citizens and support national defense.

- Product liability reform
- Multi-year federal R&D funding
- DOE restructuring
- Federal Laboratory Closure Commission
- Excess DOE Facilities Sales Enablement Act
- Intellectual Property Reform
- Critical Industry Preservation Act
- FDA reform
- NEPA streamlining to avoid project-by-project requirements (promote blanket documentation on facility/capability basis)
- Legislation to promote/enable/strengthen interagency R&D cooperation

5. Investigate Ways To re-Create or Re-Engineer US R&D System

6. Enhance Congressional Communication With US Industry Advisory Groups

C. Labs or Industry (or both) could lead

1. Support Development Of Technology Roadmaps

- E.g., Technology Partnership Roadmap pertaining to national R&D policy (with Congress as principal customer).

2. Prepare Public Service Messages

3. Conduct Workshops, PROSPERITY Games Or Other Suitable Activities

4. Consider Vertical as well as Horizontal Alliances/ Partnerships

II. TECHNOLOGY INITIATIVES

1. Explore New Technologies To Improve R→D→A→C Process

2. Develop Approaches To Science-Based Regulation

- E.g., Science-based energy and environment regulations and policies

3. Expand Labs' Biomedical Engineering Work

- Materials
- Modeling
- Small/portable/easy-to-use diagnostics suitable for domestic or third world use
- Information and communications

4. Expand Labs' Industrial Ecology Work

- Environmental surety/stewardship
- Zero emissions, clean water, etc.
- National distribution system for scrap materials
- Science-based rationale for cost effective recycling/reuse

5. Develop Telemedicine

- Issues include surety, liability, interstate licensing issues, real time, multi-platform, data base, bandwidth
- Industry see the amount of money in telemedicine as "peanuts" [which implies this is an area requiring government $ if it is to come to fruition]
- Broad, applicable experience within lab(s) including:
  1. Synchronous Optical NETwork technology (SONET)
  2. Asynchronous Transfer Mode technology (ATM)
  3. Crypto Sync Loss Detection
  4. Multidimensional, User-Oriented Synthetic Environment (MUSE)
  5. Agent-based computer programs
  6. High-performance computing and applications

6. Repeat Future@Labs.Prosperity Game

- In 1997
- Include OSTP and Administration players

7. Promote NASCI

III.FOREIGN INITIATIVES

1. **Partner With Fraunhofer Institutes**

2. **Conduct R&D Prosperity Game That Includes Foreign (e.g., Canadian, French, Japanese, and British) Labs.**

3. **Conduct Prosperity Games To Provide:**
   - Multi-cultural experiences
   - Solutions to technical/political problems (e.g., US-Japan)

4. **Pay Off US Debts To Foreign Entities By Using R&D As An "In-Kind" Exchange Medium**
   - Allows R&D in areas of foreign interest but not of national concern
   - Pays off debt with information (money stays in US, national R&D is maintained at a higher level-of-effort than otherwise possible)

Game Evaluations by Players

Game Evaluations

Several different sets of evaluations were conducted during the course of the game that are presented below. Some of the results found were expected due to apparent inabilities on the part of some players to work within the constraints of the game. Attempts to correlate the evaluation results with game play were not successful (i.e., poor attitude did not equal poor performance). Perhaps this simply means that the unhappy players were afraid of failure under the unfamiliar conditions found in the intense play of the game, but continued on as best they could and did quite well in the end! Unfortunately, dissatisfaction generally breeds, and the unhappiness of a few individual players was observed to spread to others during the course of the game by the staff.

Team Performance

After game play was concluded, each team was tasked to give a debriefing that included a self-evaluation. The specified performance scale was: 1 = terrible; 2 = poor; 3 = OK; 4 = good; 5 = outstanding. Following each presentation, all of the other teams were polled with the question of "rate the team's overall performance ..." using the same scale. The scores from these two sets of evaluations are provided for comparison in Table 16. Two teams, the IT/AMfg and OFA teams, rated themselves on a 1-10 scale. We have translated those results into a 1-5 scale as shown. Further details (means and standard deviations) of the team-by-team polling results can be found in Figure 25 through Figure 35. An additional evaluation was conducted on the part of the Congressional team when it was asked "should we reelect all congressional incumbents?" The polling results said no! Team-by-team details of the election are provided in Figure 36.

Table 16. Comparison of team performance subjective scores.

	self	*others*
Congress	5	3.35
IT/AMfg	9 (4.5)	4.03
E/E	5	3.19
LS/AMat	4.33	3.27
NS/CJ	4	3.26
DOE	3.06	3.03
OFA	10 (5)	3.83
Universities	4	4.15
NS Labs	4	3.62
S&T Labs	4	3.94
Foreign	5	3.63

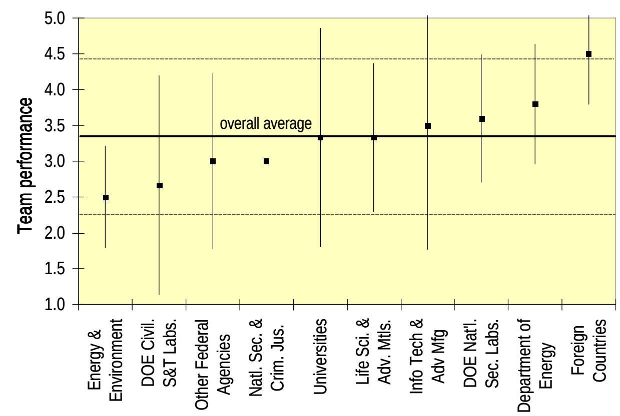

Figure 25. Other team's evaluations of the Congressional team.

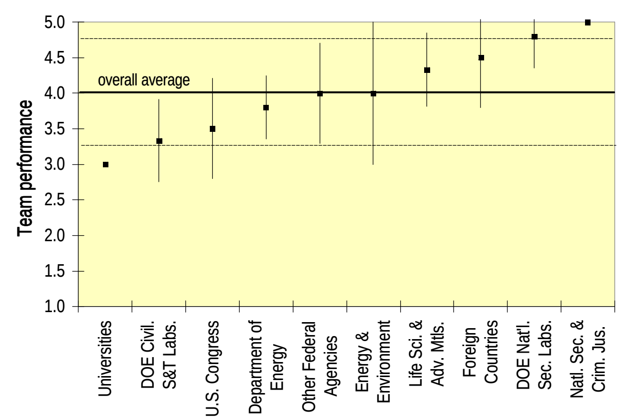

Figure 26. Other team's evaluations of the Information Technology/Advanced Manufacturing team.

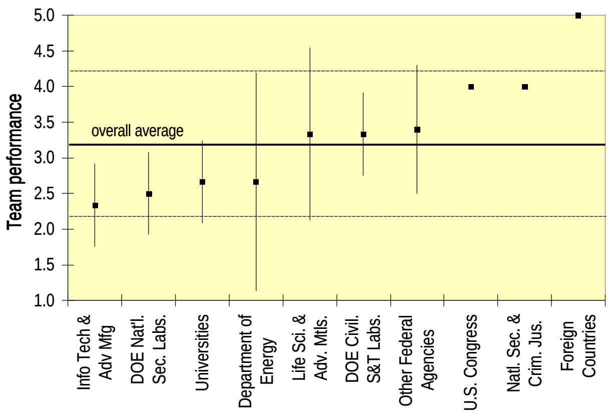

Figure 27. Other team's evaluations of the Energy/Environment Industry team.

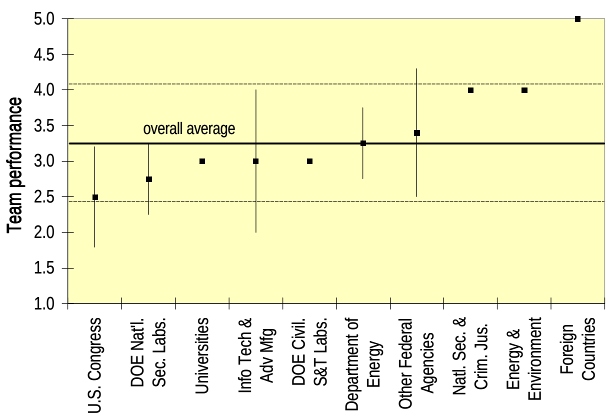

Figure 28. Other team's evaluations of the Life Sciences/Advanced Materials Industry team.

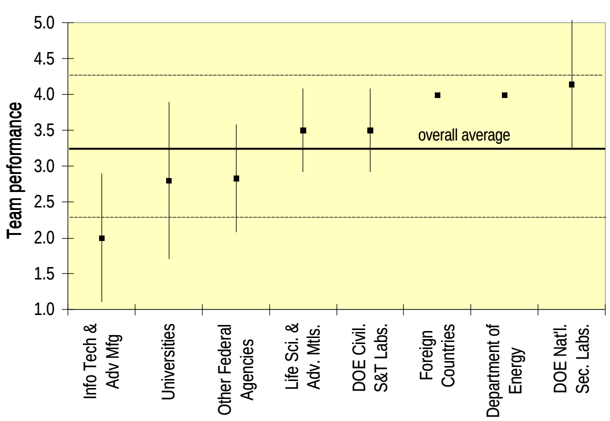

Figure 29. Other team's evaluations of the National Security/Criminal Justice Industry team.

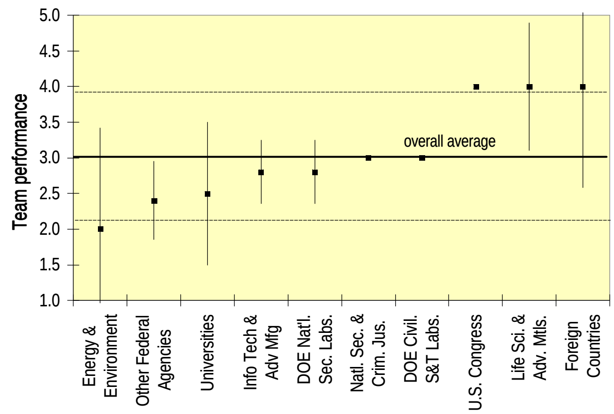

Figure 30. Other team's evaluations of the Department of Energy team.

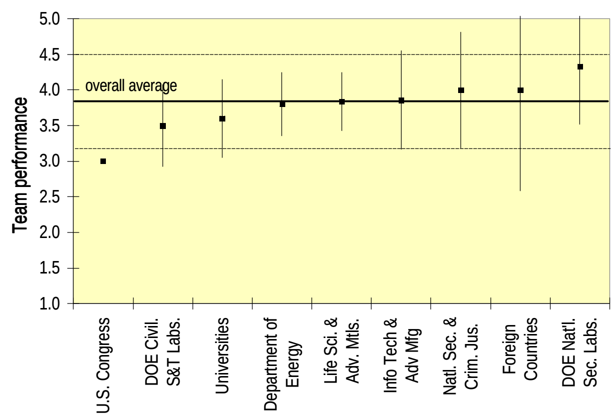

Figure 31. Other team's evaluations of the Other Federal Agencies team.

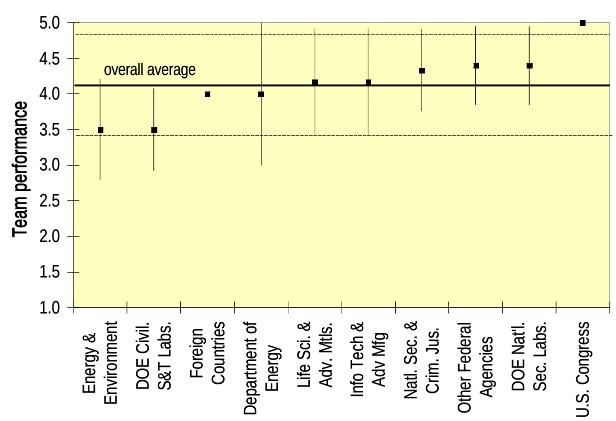

Figure 32. Other team's evaluations of the Universities team.

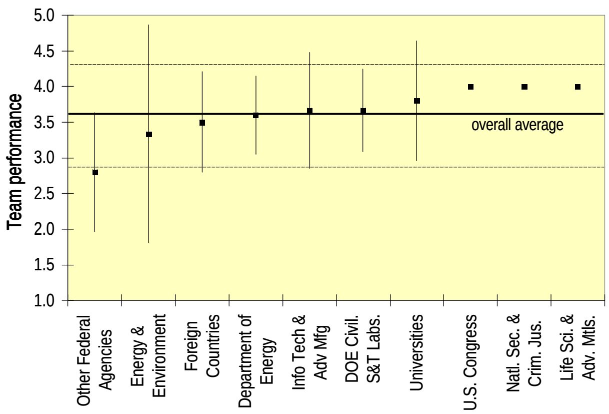

Figure 33. Other team's evaluations of the National Security Labs team.

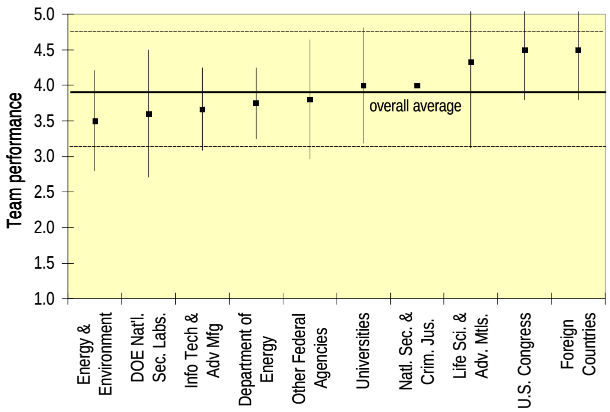

Figure 34. Other team's evaluations of the Civilian Science & Technology Labs team.

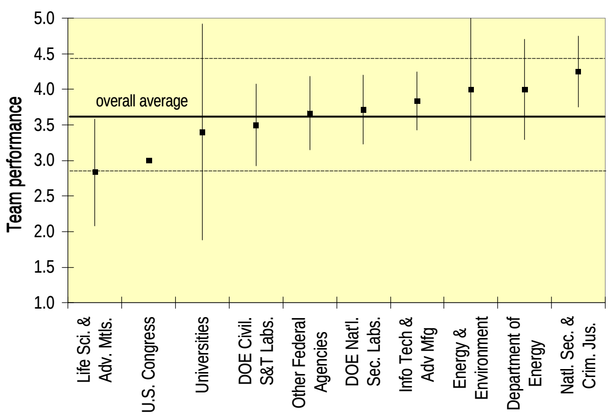

Figure 35. Other team's evaluations of the Foreign Countries team.

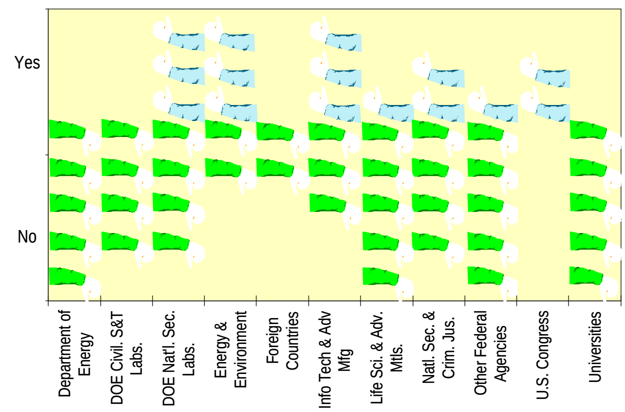

Figure 36. Congressional reelection results.

General Objectives

During the course of developing and conducting Prosperity Games™, a fairly standard set of evaluation questions has been developed. These have been useful in assessing both game design and conduct, as well as the attitudes of the players. Mean scores for these questions, as compiled from all of the Prosperity Games™, can be found in Table 17 for comparison purposes. Team-by-team details (means and standard deviations) for the current game can be found in Figure 37 through Figure 52. One strong observable trend: teams tended to always vote consistently (high, average, or low). This trend is likely a reflection of a few dissatisfied players who "fought the game," and likely tended to pull other team members down with them.

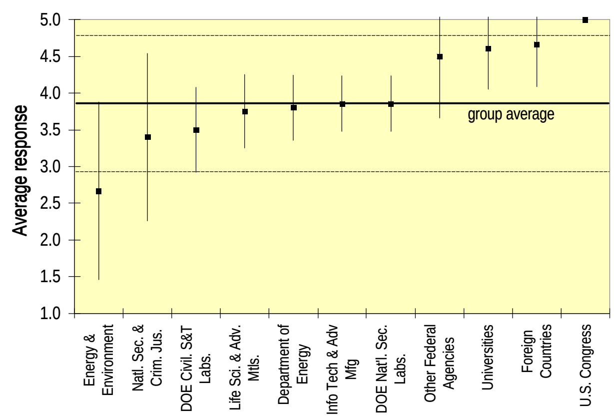

Figure 37. Did you have a rewarding experience?

Table 17. Comparison of Prosperity Game evaluation polling results.

Question and average responses by game	EIA	AEA	Adv Mfg	NEMI prot	NEMI final	ENV prot	ENV final	Univ	BIOMED prot	BIOMED final	DOE LABS p1	DOE LABS p2	DOE LABS final
Rewarding experience?						3.91	4.17	4.32	4.18	4.40	3.71	3.86	3.87
Simulate real life?						3.49	3.63	3.94	3.57	3.40	2.85	3.21	3.33
Broaden perspective/new ideas?						3.85	3.38	4.19	3.79	4.42	3.38	3.65	3.53
Accomplish sponsors' objectives?						3.51	3.43	3.80	3.58	3.49	3.12	3.12	3.33
Meet your objectives?						3.57	3.61	3.77	3.93	4.02	3.14	3.60	3.58
Maintain interest and enthusiasm?			4.29	4.61		4.02	4.02	4.27	4.24	4.28	3.65	3.89	3.96
Stimulated thinking on future technology policy?	4.07	3.68	4.29	4.64	3.83	3.56	3.37	3.84	4.14	4.43	3.97	3.56	3.73
Facilitated understanding of roles and relationships (develop relationships among players)	(3.33)	(3.05)	3.53	3.46	(3.94)		3.64	3.93	3.76	3.95	3.74 (3.69)	3.68	3.51
Long-term thinking and planning?	4.02	3.68	3.59		3.89	3.02	2.69	3.52	3.57	3.55	3.26	3.34	2.87
Laid foundation for industry to make tech roadmap (How valuable would a roadmap be?)	3.70	2.42			3.38				(4.30)	(3.79)	3.08		
Would you play a full 2-day game with peers	3.74	3.95	3.82			3.78			3.80				
Worth the time spent?							3.71	4.32		4.00	3.61	3.91	3.70
Recommend that others play full 2-day game	4.31	4.16			4.36	4.13	3.86		3.90	4.30	4.15	3.77	3.69
Format of the games	3.31	2.68		3.61	4.25	3.72	3.73	3.29	3.76	3.71	3.03	3.56	3.65
Innovator decision aid	4.12	4.05			3.38								
Players' Handbook	2.87	3.00			4.29	3.73	3.91	3.03	3.37	3.64	3.22	3.07	3.77
Prosperity Games staff helpfulness/effectiveness?	4.09	4.53			4.79	4.49	4.88	3.94	4.67	4.86	3.68	4.31	4.64
Played assigned role effectively?	2.96	3.11	3.82			3.89	3.93	4.00	4.10	3.93	3.53	3.60	4.08
Players controlled the content?	4.38	4.42			4.59	3.66	3.66	3.94	3.75	3.46	3.91	3.76	3.89

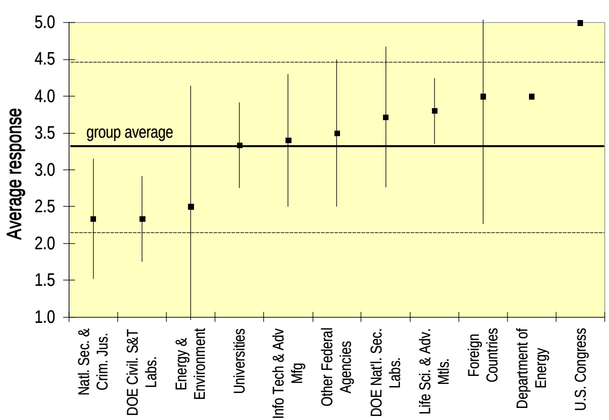

Figure 38. Did the game simulate real life (albeit on an extremely short schedule)?

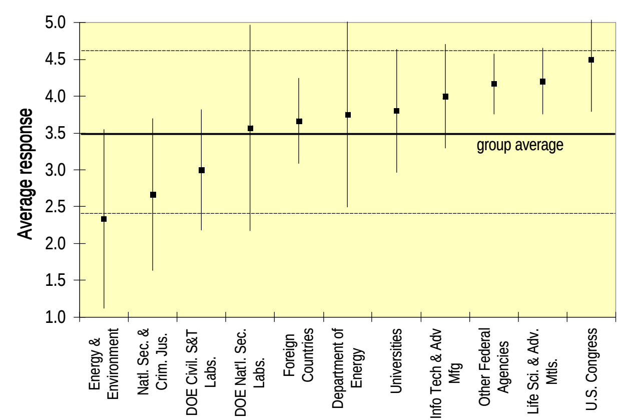

Figure 39. Did the game broaden your perspective and introduce new ideas?

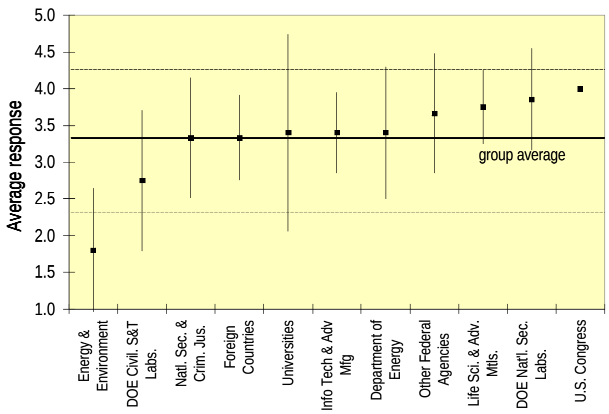

Figure 40. How well did the game accomplish the objectives of the sponsors and designers?

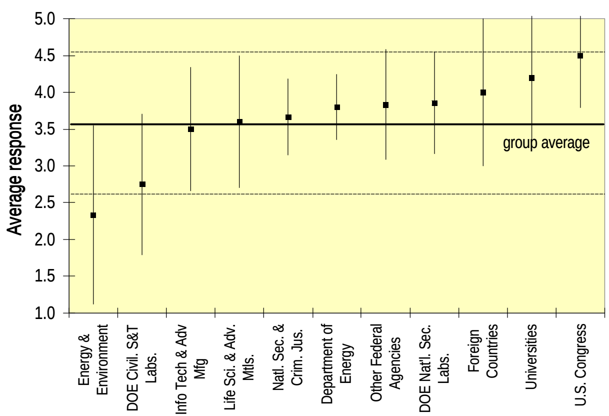

Figure 41. How well did the game meet your objectives?

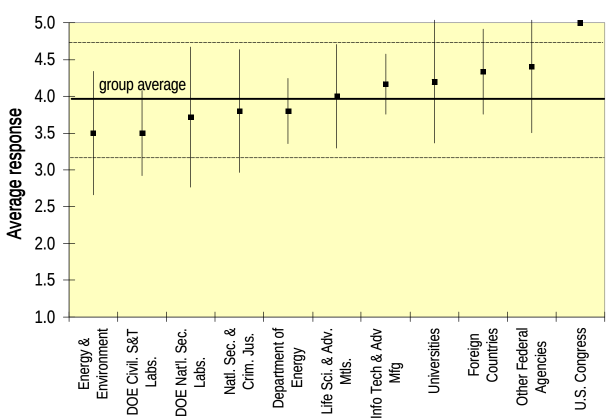

Figure 42. To what extent did the game maintain your interest and enthusiasm?

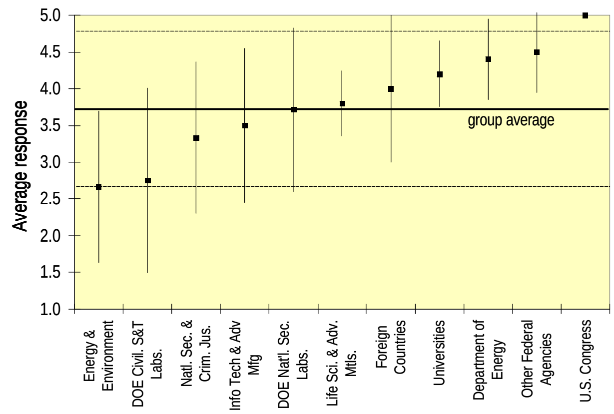

Figure 43. Did the game stimulate thinking on future technology and public policy?

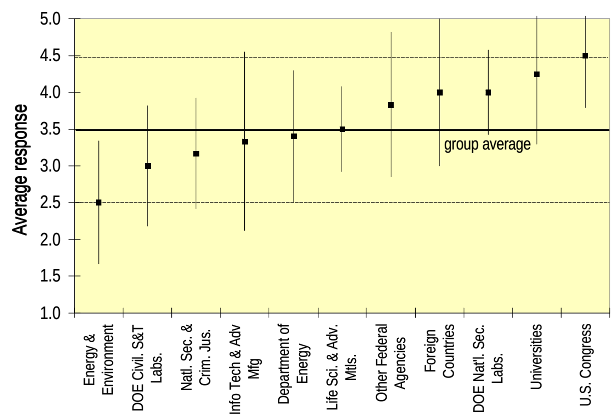

Figure 44. Did the game help you understand the roles and relationships among players?

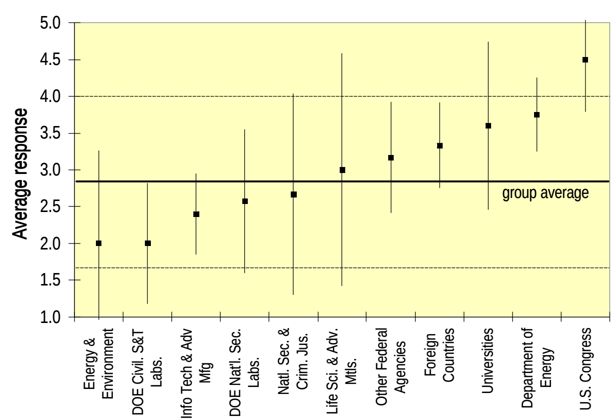

Figure 45. Did the game explore long-term thinking/planning?

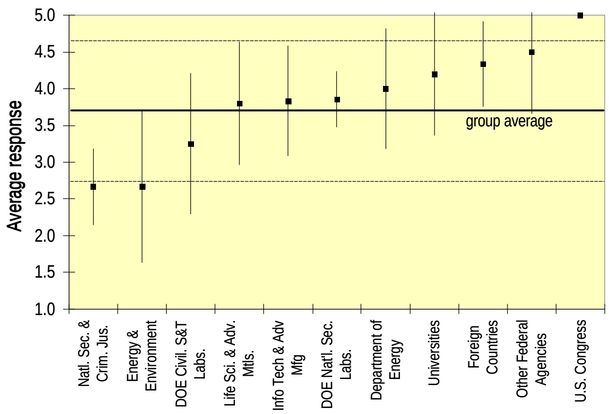

Figure 46. Was the Prosperity Game event worth the time spent?

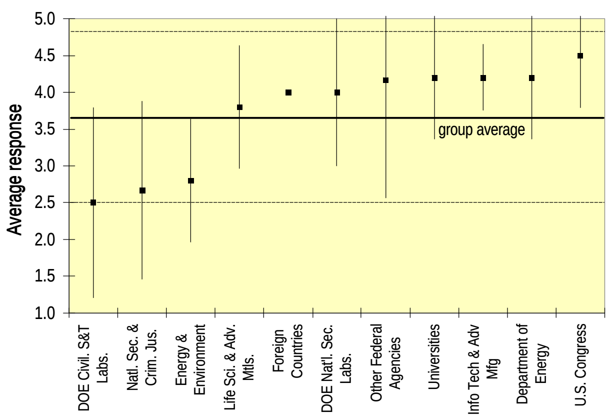

Figure 47. Would you recommend that others play a 2-day Prosperity Game?

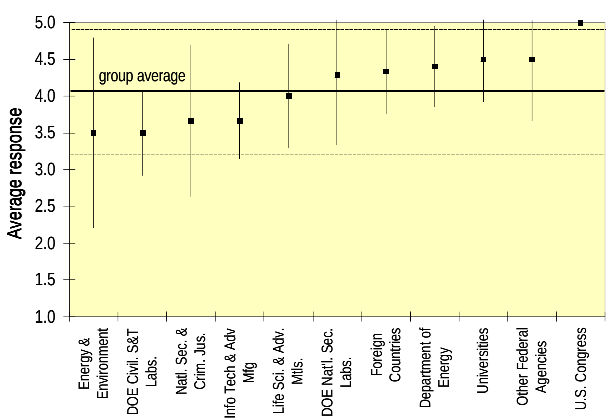

Figure 48. To what extent were you able to play your assigned role effectively?

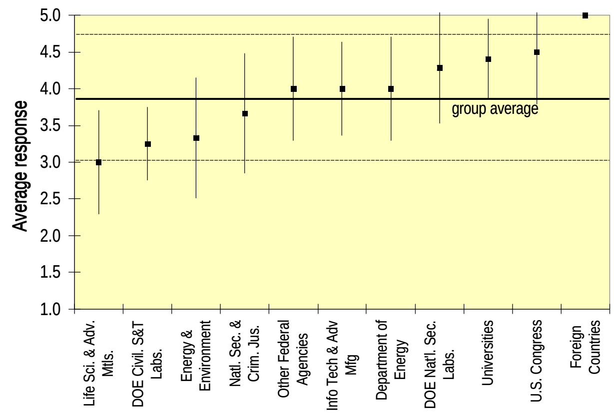

Figure 49. To what extent did the players control the content?

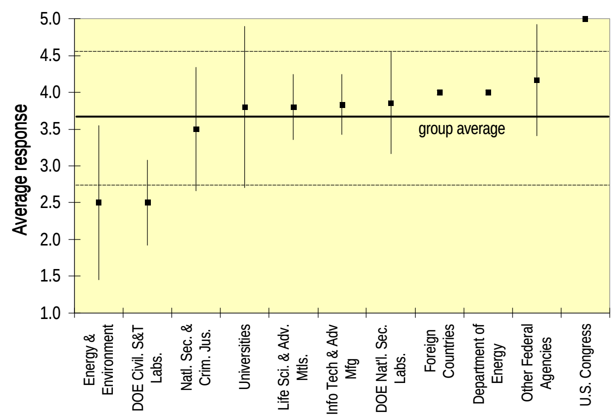

Figure 50. Rate the format of the games.

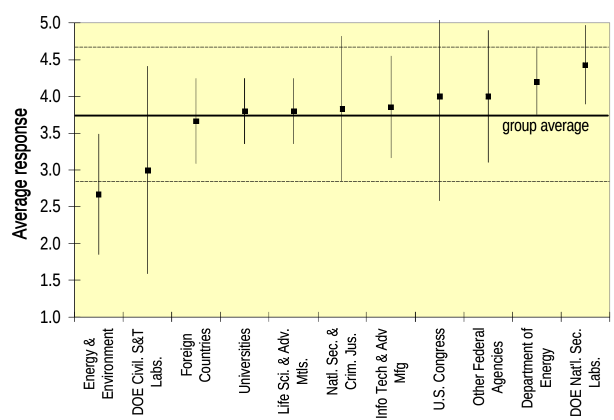

Figure 51. Rate the Player's Handbook.

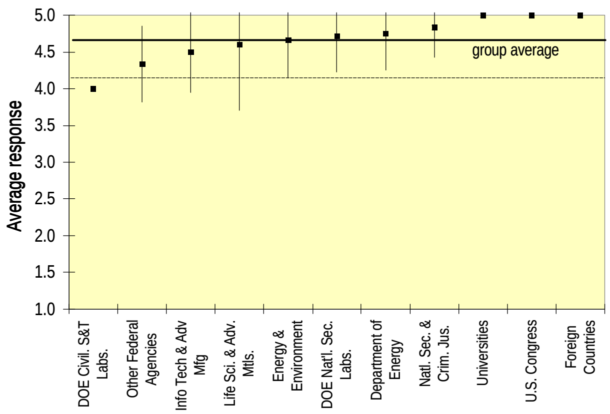

Figure 52. Rate the PG staff helpfulness.

Entry & Exit polling questions on R&D

In order to evaluate the attitudes of the players regarding R&D, and any changes in that attitude that may have resulted from playing the *Future@Labs.Prosperity* game, a series of eight questions were posed. The questions were asked both pre- and post-game. In general, as might be expected, the audience was very supportive of R&D, even at the expense of social programs and reductions in the federal deficit. Apparent changes in overall attitudes were observed as a result of the game that included:

1. R&D is more important to the future quality of life than first envisioned.
2. Partnerships among labs, industry, and universities is more important to the nation than first thought.
3. The players are more familiar with the capabilities and facilities of the labs as a result of the game.
4. The idea of expanding the missions of the national labs beyond their current role decreased to just above neutral by the end of the game.

Some individual teams had dramatic shifts in opinions on one or more questions, and these did not always correspond with overall responses. These details can be found in Figure 53 through Figure 60 below.

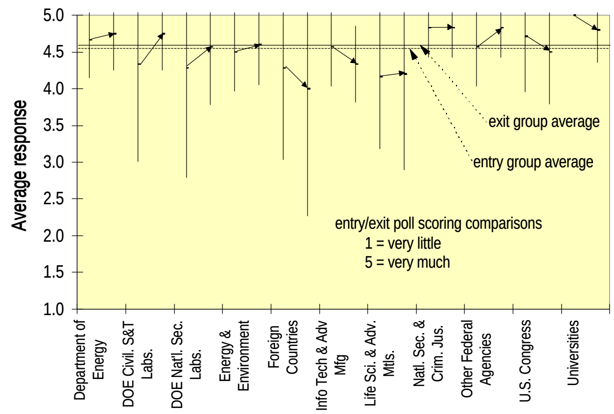

Figure 53. How important is R&D to the economic health of the US?

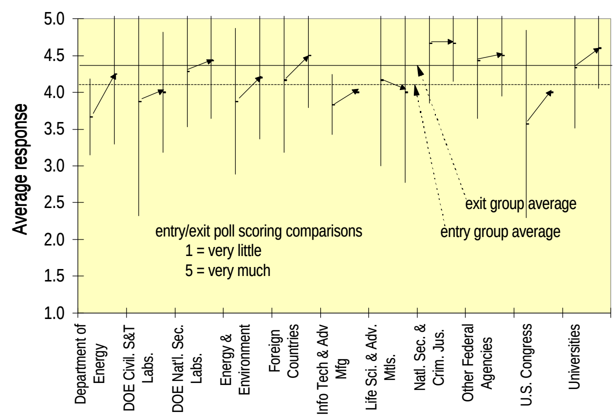

Figure 54. How important is R&D to the future quality of your life?

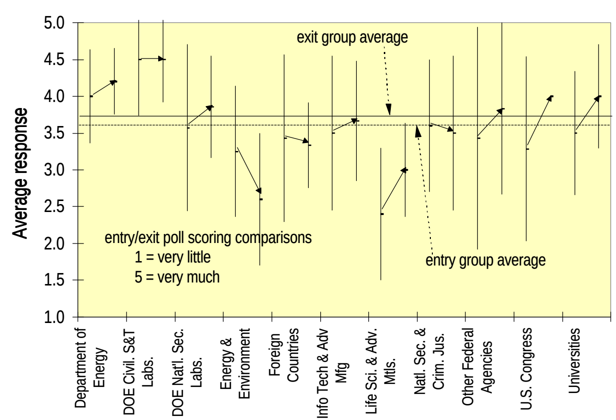

Figure 55. How important are the national labs to the national R&D delivery system?

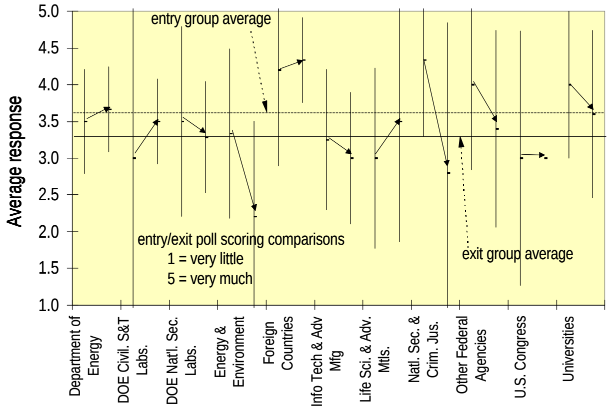

Figure 56. How much should the missions of the national labs be expanded beyond defense needs (beyond their current definitions)?

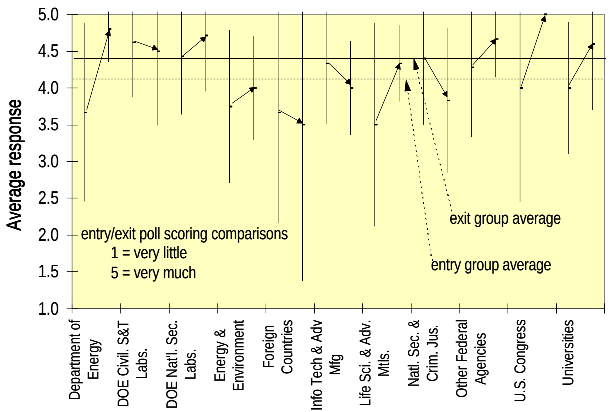

Figure 57. How much would partnerships among labs, industry, and universities benefit the nation?

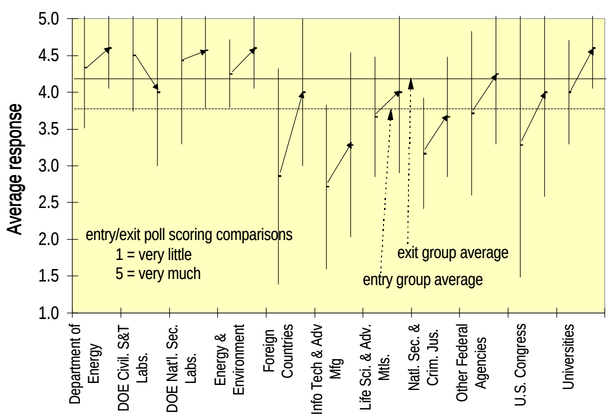

Figure 58. How familiar are you with the labs' capabilities and facilities?

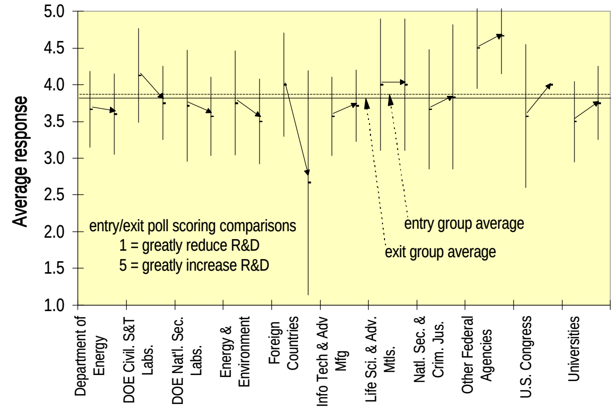

Figure 59. In tradeoffs between Federal funding for R&D and funding for social programs, we should:
1 = greatly reduce R&D to
5 = greatly increase R&D.

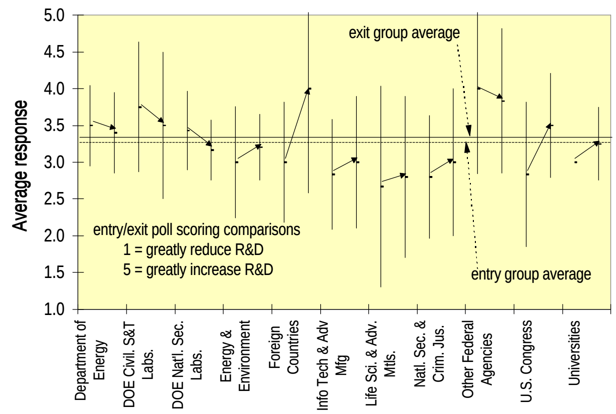

Figure 60. In tradeoffs between Federal funding for R&D and increasing the federal deficit, we should:
1 = greatly reduce R&D to
5 = greatly increase R&D.

Lessons Learned

Following are some of the comments provided by the players in written evaluations.

Game Benefits/General

- An important activity for bringing different cultures, different priorities to the forefront and open to discussion.
- Stimulating, enjoyable, intense, draining, well organized and planned.
- Participation in these Prosperity Games was a valuable and rewarding experience. As someone who's real-life responsibility is partnering and collaboration, it was most beneficial to get others' perspectives and attitudes toward partnering.
- Some concepts were close enough to reality to be useful (e.g., joint appointments between universities and labs).
- Good game experience and I learned a lot. I believe the games to have many indirect benefits in terms of relationships and opportunities to be followed and built on.
- An enriching experience. The game provided an opportunity for us to reaffirm the essential importance and role of universities in the new world order. The planning and game design were excellent. The pace of learning was quick, but there was adequate time for reflection.
- Game was an excellent exercise. A major factor in its success was the caliber of the participants and their enthusiastic participation. Atmosphere was terribly frantic, but perhaps that contributed to the success. Being all together in one room made it difficult to concur.
- Amazed at how much is similar to reality in this accelerated game.
- Fun.
- The initial hectic pace and paucity of information on how the game worked were very true to normal industry operation.
- I really enjoyed the interactions between the various teams—it really made me think about the constant petitions the Congress and the difficulty of developing a comprehensive view on strategy to deal with problems or issues.
- Thought the meeting was very informative and realistic - a brilliant idea!
- Personal and team dynamics were realistic and stimulating.
- Great interactions/great fun.
- This was a good beginning in defining what is needed to insure future prosperity of our national labs. We need to begin thinking outside of the box and define our own future—rather than living in the past (every day we do what we did the day before).
- Excellent experience, well organized; the game did reflect real life more than anticipated.
- The game stimulated my thought process on how to partner better with other federal agencies and industry.
- Very useful game—stimulated thinking, created the potential for future initiatives and built a network of interested parties who can make things happen.
- Developed a better understanding of need to partner and to market lab capabilities.
- Basically an engaging process. Learned some things that will be useful. Worth the time invested.
- The game was thought provoking and the interplay of ideas with the other players was very interesting.

Game Design

- Add more dramatic, unplanned events affecting investments made in the game.
- Have separate money for policy options in tool list to encourage policy items.
- Reporting out at end is "too slow." Need to end on a high note.

- Very well conceived and run.
- More opportunity for people to think of and try out approaches beyond their comfort zone (with the time pressure, this was hard to do).
- Improve discipline and realism of the ROI on "deals."
- Overall - excellent. Would like to find a vehicle to get at the specific policy/organizational issues and incentives earlier than the last day.
- A single session immediately after the R&D Summit which allows representatives/ambassadors to address Congress on 1) national technology initiatives and 2) funding/tax incentives would generate cross-dimensional problem solving - and be the foundation for Session 5. Incentivize partnerships with Foreign Governments through a separate session.
- Very well executed game. Strengths: effort to incentivize teams, give real-time feedback, alter the strategic environment. Weaknesses: very broad focus, lack of expertise on teams.
- Inject "crises" that affect each team differently; i.e., each team has a 'piece' of information others do not have.
- Recommend three full days.
- Well organized, fast moving.
- More 'examples' and templates of possible actions.
- Either an off-site introduction in Defining the Future to break the present paradigms, or more Prosperity Games focused on giving history of previous games (failures) first—then start the new one.
- Resources of "Other" and "Control" needs to be elaborated.
- Improvements: "Foreign Countries" had to play two very different roles by representing developed and developing countries—next game should have two teams. Allow more time to find out roles of different teams. Find a way to ensure that teams have to stick better/more to the objectives of the game (did we help to deliver the answers that DOE/the Labs are looking for?). Progress of the sessions was too-much money oriented.
- Insufficient addressal of national security issues, given the scenario. Play concentrated on "feel good" aspect of life. National security labs should not play too much in that.
- Need strong DoD representation for reality; DoD/NS interests not adequately covered.
- Game too fast paced to allow some strategic thinking. May want to consider a longer game or fewer sessions.
- Industry people would NEVER spend a dollar without VERY CLEARLY understanding the connection between their action and the resulting profits.
- Credit for policy initiative implementation would foster more teaming, more outside/environmental influences on the game.
- Some way to foster more innovative, potential solutions to issues facing the labs and how they can partner with other entities needs to be built into the games.
- Need a realistic way to value the labs' contribution of technology to a partnership. Value of labs tech base far outweighs any $ investment from labs. Need approach for industry to understand labs' capabilities; we relied on personal knowledge of players—which worked pretty well.
- Intellectual property issues not addressed; in reality, they often impede broad partnerships.
- Labs needed a way to value technology to enter into deals beside $. Labs didn't have much to deal with.
- The game did not adequately highlight the benefits of cooperation between DOE entities and industry.
- Unclear how one investment relates to (supports) another. Toolkit options role unclear too.
- Tighter connection between investments and summit meeting discussion. Greater coupling between investments and specific other teams - too much emphasis on who had $.

Processes

- Improve communication about how investment programs will be evaluated (ROI, successes, failures, etc.)
- Modify to ensure that news and regulatory changes are communicated to all participants.

- Provide more feedback on impact of projects on goals and give incentives as appropriate for jobs, balance of trade, etc.
- A shorter more intuitive advance reading assignment.
- No perceivable connection between "News" broadcasting or "Prosperity News" and game consequences.
- Press releases on Congressional and other activities would have helped the "game."
- Real-time feedback on the outcome metrics described in the handbook would be nice after each round.
- Need more dramatic feedback.
- Need a way to keep score.
- More detailed feedback in real time. In general, the game is excellently facilitated and accomplished an amazing breadth of play in a short time.
- Mechanics were very impressive. Some greater ability to change federal spending allocations would make it more realistic (it would bog down the Congress!).
- Information on current events was limited. Agreements were made that would have interested us, but we didn't find out til end of game.
- I would recommend that the panel and speaker summary presentations be recorded.
- Should be more communication between initial invitation in January and next mailing in April! Should be more precise about making your own reservations at hotel (not automatically made).
- Positives: Organization and participation were excellent; timeframe covered was good—too much further would be unrealistic; material handouts were well done and helped 'realism'; facilitators were good in that they 'let us find our way'; most groups seemed to act as would be expected. Negatives: Congressional team was not responsive and did not seem like players; financial status reports were poor. Recommendations: Prepare real-time financial status reports.
- It was a struggle to factor time and change into each new round. It might help to specifically restate the world—maybe a state of world and technology annual message.
- Need better Admin. information in advance (i.e., dress, block of rooms reserved - how many: - any costs, etc.). Put the important announcements in writing and distribute to each team. Don't rely on PA system (many ignored). Newspaper was excellent, but only for 1 day? Staff was excellent. Very helpful and cracked the whip gently. Shorten (to 3 min.) the wrap-up briefing. Challenge the briefings to stay on time.
- Did not leverage previous session outcomes; needed help in re-setting timeline / new global environment.

Environment

- Improve daily communications - acoustics were bad and the speakers did not demand attention. The game premise highlighted the need for each of us to expand partnerships beyond our normal environment.
- Need better sound equipment and more focus on getting all the groups' attention during announcements.

Players

- Industry participants were involved or biased toward lab so that result may not reflect national feelings.
- Some mixing of participants between groups (teams) - cross-seating at meals (back-up groups at times).
- Would not have hurt to increase number of participants by 20%.
- Good diverse group of people.
- The game should be organized a little differently so that we come to know people from other tables better. There is no time for much interaction except during the first evening's introduction session.
- Provide short bio of all players upon arrival (one-three paragraphs to help build relationship / bonding).
- In permitting the participants to get to know each other (a major objective of coming here), the game structure did not allow sufficient time for

socialization. Holding the games in a more isolated location and providing for dinners might achieve that (like a conference or scientific workshop).

Appendix A: Handbook Materials

Team Descriptions, Challenges, and Opportunities

US Congress

You represent members of the Senate and House of Representatives committees and subcommittees. These have been difficult times for Congress. The public has a low perception of Congressional integrity and competence. The President and Congress often find themselves at loggerheads. The national debt is growing enormously, despite recent reductions in the annual deficit. Public confidence is very low. Some government entitlement programs have been projected to go bankrupt in the near future; e.g., Medicare in 2002 and Social Security in 2031. Nevertheless, you wield enormous power for change for the better or for the worse.

You are interested in exploring new ways in which the laboratories could function more effectively and more readily sustain themselves financially. The Senate is currently investigating all FFRDCs (DOE, DOD, NASA, EPA, etc.) to reduce costs and to better address national problems. You also have concerns about the trend for certain laboratories to engage in technology transfer activities, the possibilities of "corporate welfare," and potential competition with industry. You seek to direct the scientific and engineering resources of the federal laboratories toward the economic, environmental, defense, scientific, and energy needs of the United States in a more effective and efficient manner. You are especially concerned about the ability of the US to compete globally, and the role played by science and technology in this international competition.

Revenues for the future are fixed; however, if savings are realized, they can be applied to other governmental programs or to reducing the national debt. You need to develop a list of requirements, assign priorities, and allocate future tax income. Creative solutions are encouraged. You should consider technology priorities, quality of life issues, time lines, and metrics to judge your progress. However, given the differing viewpoints among the voters, you must make a strong case for your proposals in order to be reelected.

Challenges:

- Outline your objectives for national R&D and the appropriate role of the federal labs; prioritize policies and technologies that will help you accomplish these objectives.
- Consider changes that might occur over the next 10-20 years, and how these might affect your objectives. Are your strategies sufficiently robust to handle these events?
- Ascertain the appropriateness or inappropriateness of the existing structure of the federal laboratories with respect to being located within DOE, and with respect to contracting for the laboratories' management with industrial corporations and universities (Government Owned, Contractor Operated - GOCO).
- Decide whether or not a separate agency should be formed in which all or some R&D government organizations should be placed (with emphasis on the federal laboratories).
- Determine if the federal laboratories should perform research outside DOE's traditionally mandated areas of responsibility, which are national security, energy, and environmental remediation, and if so, in what areas.
- Determine whether the federal laboratories should be restructured, consolidated and/or managed as a system, and if so, how?
- Propose new legislation that would mitigate your concern about the functioning of the federal laboratories, including any concerns relative to the lack of coordination/management among programs within the laboratories.
- Determine the allocation of revenues to the various stakeholders and programs. Note that the R&D allocation may be increased, but only by taking funds from other existing programs such as Social Security or Medicare, or by increasing corporate taxes or increasing the deficit. See Appendix B-2 for more data.
- Develop and pass new legislation dealing with R&D, the introduction of new technologies, and the role of science and technology in international economic competition.
- Discuss and debate values and the appropriate role of government. Seek stakeholder inputs. Apply these values in proposed legislation.
- Consider reelection issues.
- Develop an appropriate set of metrics to measure the cost of government programs, their efficacy, and the return on taxpayer investments.

US Industries/Companies

You represent corporate America. You are interested in technical development which will result in enhancing your position in the marketplace; you are willing to enter into collaborative agreements with appropriate organizations for the research, development, and licensing of technologies which you believe your company can commercialize. You are concerned about specific "gray area" directives which govern the laboratories' ability to enter into such collaborative and joint venture agreements. You would like to simplify and expedite the CRADA process. You are also concerned about competition from the laboratories, and issues concerning ownership of intellectual property.

Your team is focusing on certain technology areas. However, you may partner with other teams to pursue common technologies or specific policies which you favor.

An industry team may form consortia among its own players or other industry teams, or form two or more conglomerates or sectors; however, it cannot represent a single company.

Challenges:

- Develop a strategic plan or roadmaps for your industries that outline your objectives, and the policies and technologies that will help you accomplish them.
- Consider changes that might occur over the next 10-20 years, and how these might affect your objectives. Are your strategies sufficiently robust to handle these events?
- Learn about the core competencies of each laboratory and institution, and develop procedures for collaboration and cooperation.
- You are concerned about the close relationship (privileged information to potential competitors) between the managing corporation and the laboratory with which you are interested in entering into agreement. Develop new ways and means to assuage your concerns by the implementation of changes to the federal laboratory management system.
- Generate a concept, a strategy, and salient points of future legislation that will enable you to more adequately deal with federal laboratories.
- Outline your concerns about unfair competition and negotiate them with all involved stakeholders.
- Evaluate the tradeoffs between tax incentives for R&D and the availability of technologies, people, and facilities from labs and universities.
- Develop ways in which the resources of the federal laboratory system will complement rather than compete with industry laboratories. Since long-term research performed by industry laboratories is declining, determine the feasibility for industry to rely more heavily on the federal laboratory system to provide long-term research germane to industry's needs in specific areas.

Department of Energy

You represent the Department of Energy with a focus on federal laboratories; their management, mission adequacy, and effectiveness in meeting the requirements placed upon them.

Your mission is to contribute to the welfare of the nation by providing the technical information and scientific and educational foundation for technology, policy, and institutional leadership necessary to achieve efficiency in energy use, diversity in energy sources, a more productive and competitive economy, improved environmental quality, and a secure national defense.

You are aware of concerns as to whether or not the current structure of the laboratories is the most effective. Excessive oversight and micromanagement are criticisms directed at DOE relative to management of its laboratories. Greater integration among applied energy programs has been cited as needed within the laboratories. Some have questioned the appropriateness of the laboratories being under the jurisdiction of DOE.

Environmental waste cleanup is a major DOE assignment. GAO estimated a cost of $1 trillion dollars to clean up DOE's waste sites. Total cleanup of waste sites in the US is estimated at $1.7 trillion dollars. Some experts state that new environmental technologies are required to lower costs and increase efficiency.

However, many people question not only the validity of your mission, but whether the department should continue to exist as it is currently structured.

Challenges:

- Develop a strategic plan outlining your objectives, and the policies and technologies that will help you accomplish them.
- Consider changes that might occur over the next 10-20 years, and how these might affect your objectives. Are your strategies sufficiently robust to handle these events?
- Study the advantages and disadvantages of the transfer of the laboratories to another agency.
- Consider a conceptual design for a new agency that would include the laboratories and other government

R&D entities and provide a list of reasons stating why this would or would not be appropriate.
- Generate a list of pros and cons for contracting the laboratories' management to private industry corporations.
- Develop a strategic position about the environmental cleanup requirements for which DOE is legally responsible.
- Design a synergistic strategy which will simultaneously address DOE's responsibility in the areas of nuclear weapons (stockpile security and reliability), national energy sources, environmental cleanup, and ecological sustainability.
- Determine DOE's desired role in developing science and technology for increasing the US's international competitiveness.
- Interact with other teams with respect to your findings, suggestions, and proposals.
- Use your influence to change laws and regulatory practices.
- Lobby Congress for the resources you feel you need, and allocate those funds to laboratories and other R&D organizations.

Other Federal Agencies

The DOD is by far the major contributor to Federal R&D (~52%). To serve your mission of defending the country, you need to be at the forefront of new technology. You support research at your labs, the DOE labs, universities and industry. Your goal is to maintain defense superiority through technological improvements, and to get the best new technology at the lowest cost. Since your capabilities are provided by industry, it is important to work with industry and encourage dual use. You need to balance the value provided by the labs in advanced concepts with that provided by industry.

Additional significant research is funded by the National Institutes of Health (16%), the National Science Foundation (4%), NASA (12%), EPA, the Nuclear Regulatory Commission, and the Departments of Commerce, Agriculture, Transportation, and other federal agencies.

Challenges:
- Develop a strategic plan outlining your objectives, and the policies and technologies that will help you accomplish them.
- Consider changes that might occur over the next 10-20 years, and how these might affect your objectives. Are your strategies sufficiently robust to handle these events?
- Determine priorities for the new technologies that would enable you to better accomplish your missions.
- Determine ways and means to acquire these new technologies.
- Assess the reliability of the nuclear stockpile, and DOE's commitment and capability to maintain the necessary readiness.
- Determine the most effective way to use the combined strengths of universities, industry and federal laboratories.
- Assess the GOCO (Government Owned, Contractor Operated) federal laboratories' management system relative to your interests in the federal laboratories, determine appropriate changes, and pursue these changes.
- Interact with other teams with respect to your findings, suggestions, and proposals.
- Use your influence to change laws and regulatory practices.
- Lobby Congress for the resources you feel you need, and allocate those funds to laboratories and other R&D organizations.

Universities

Many universities, like federal laboratories, have departments or affiliated organizations that perform research and development. The federal laboratories and universities encounter similar obstacles in maintaining adequate funding, acquiring and retaining expert personnel, and receiving proper remuneration for the technologies produced. Due to funding reductions in government allocations and in university budgets, officials in both institutions encounter the problem of altering their operations to compensate for the reduced budget allocations. Political considerations are always germane. Educational trends, such as remote education, industries' disenchantment with higher educational institutions' products (graduates), industries' rapid technological change, the increase in the number of short-term tech-schools, and the rising cost of conventional education, present difficult challenges to universities. In many cases, you see the federal labs as your competitors, taking away resources that you feel could be better spent at universities.
Your task is to consider the salient points in the rapidly changing educational field within the context of finding new ways to cooperate, joint venture or partner with federal laboratories and industry.

Challenges:
- Outline your objectives, and the policies and technologies that will help you accomplish them.
- Consider changes that might occur over the next 10-20 years, and how these might affect your objectives. Are

your strategies sufficiently robust to handle these events?

- Suggest innovative ways in which universities and federal laboratories can cooperate that could solve some of the existing university problems and mutually enhance the probability of additional revenue for both.
- Determine the most promising of these innovative possibilities, create a strategy for implementing these possibilities, and explore them within the context of the game.
- Seek funding to support your strategies.
- Explore the balance of domestic versus foreign funding of university research, and the implications of this split. List your concerns, if any, with respect to federally funded laboratories competing with university laboratories. Determine how these concerns could be resolved and take appropriate action to make these changes.
- Explore concerns related to the licensing of intellectual property to foreign companies.
- Negotiate with appropriate teams to implement your strategy and achieve your objectives.

DOE National Security Labs

You represent the weapons laboratories (Sandia, Lawrence Livermore, Los Alamos, ASKC). With the winning of the cold war, your mission has come under scrutiny. Although you have much to contribute to the nation's welfare, you are very concerned about the labs' future. Although national security and science-based stockpile stewardship are essential for the foreseeable future, they will probably not be adequate to maintain the quality of staff and facilities that you need.

Energy and environmental cleanup remain important missions. However, neither is viewed by the public with the same sense of urgency as the past national defense mission. The US public often maintains a crisis mentality that does not strongly support investments in impending but not immediate problems. However, you consider your capabilities to be a national resource to meet many national needs, and not just your current missions.

Congress has not unanimously accepted new missions, and budget cuts are almost certain. Attacks on DOE as the managing agency have not helped your situation.

In a period of great uncertainty, you must carefully define your missions and your customers, and educate the public and government on your capabilities and potential contributions. Simultaneously, you must develop partnerships with industry and universities to alleviate turf and funding issues, resolve questions of competition, and develop strong synergies.

Challenges:

- Develop a strategic plan outlining your objectives, and the policies and technologies that will help you accomplish them.
- Consider changes that might occur over the next 10-20 years, and how these might affect your objectives. Are your strategies sufficiently robust to handle these events?
- Discuss plans and concerns about continuing to be the stewards of the nation's stockpile: safety, security, reliability, readiness.
- Determine how weapons research and production, as well as all other programs, can be accomplished in a more cost-effective manner: how to increase productivity and lower costs? value of partnering? benchmarking? reducing duplication?
- Seek appropriate collaborative agreements among the weapons laboratories and other federal laboratories, universities, industry, and foreign interests.
- Discuss the current GOCO (Government-Owned, Contractor-Operated) management system and other alternatives, including sponsorship by DoD rather than DOE, privatization, or corporatization. How would the labs respond to these situations?
- Determine what additional areas of research and development are appropriate to pursue within the weapons laboratories. Substantiate your conclusions. Pursue activities that would enable the weapons laboratories to perform such research.
- Create brief position statements about the environmental cleanup requirements faced by DOE, determine appropriate objectives and strategies relative to the weapons laboratories' capabilities in the area of environmental cleanup, and pursue activities appropriate to your conclusions.

DOE Civilian S&T Labs

You represent the DOE federal laboratories other than the weapons laboratories, including ANL, ASKC, BNL, INEL, LBNL, NREL, ORNL, and PNNL. You have concerns with respect to the effectiveness of the laboratories' management system, the reported low morale among personnel, competition between labs and universities, and between the labs themselves, and whether or not the metrics or measurements of laboratory performances are adequate. You share many of the same concerns and problems as faced by the weapons labs, but you lack the continuing weapons mission. However, you consider your capabilities to be a national resource to meet many national needs, and not just your current missions.

Challenges:

- Develop a strategic plan outlining your objectives, and the policies and technologies that will help you accomplish them.
- Consider changes that might occur over the next 10-20 years, and how these might affect your objectives. Are your strategies sufficiently robust to handle these events?
- Determine the major areas of R&D competence in your laboratories. Which areas should be pursued by which labs?
- Create a strategy for successfully pursuing these areas of research on a long-term basis and implement this strategy.
- Seek appropriate collaborative agreements with the weapons laboratories, other federal laboratories, industry laboratories, and university laboratories.
- Assess the GOCO (Government Owned, Contractor Operated) management system, list suggested changes, and actively pursue these changes.
- Create brief position statements about the environmental cleanup requirements for which DOE is responsible, determine appropriate objectives and strategies relative to possible laboratories' capabilities regarding cleanup requirements and pursue activities appropriate to your conclusions.
- Suggest changes that would enhance personnel morale.
- Develop a better system of measuring performances of the laboratories.
- Determine the roles, if any, of your laboratories in long-range development of national sustainable energy sources.
- Determine the roles, if any, of your laboratories in the development of the new field of "industrial ecology."

Foreign Countries

You represent dignitaries and officials from industrialized and developing foreign countries, representing both industry and government. You are interested in pursuing new relationships between your countries and the United States relative to entering into new agreements which would be mutually beneficial to your countries and to the United States and, particularly, DOE's federal laboratories. You are currently contributing 15% of the industrial R&D performed in the US. Your investment has contributed to offsetting the extremely low savings rate in the US. However, you are also concerned about some political movements that seem isolationist and threaten to increase tariffs and restrict trade. You are also concerned about intellectual property ownership.

Challenges:

- Develop a strategic plan outlining your objectives, and the policies and technologies that will help you accomplish them.
- Consider changes that might occur over the next 10-20 years, and how these might affect your objectives. Are your strategies sufficiently robust to handle these events?
- Determine which policies and technologies you wish to invest in.
- Develop an overall strategy whereby your countries could acquire energy and other technologies created at the US federal laboratories and present proposals to the appropriate teams to realize these strategic objectives.
- Determine how international technology transfer and technology licensing could more easily be realized from technologies developed at federal research laboratories.
- Define what your countries' core competencies are. Devise new ways to collaborate on technological development between your country and the US, especially on high-risk, high-payoff R&D investments (e.g., fusion, particle accelerators).

Control Team and News Media

Members of this team include representatives from various disciplines and fields, such as news media, legal, public relations. Members of this team will interact with members of other teams in such a manner as to simulate world reactions to events transacted by other team members. Members of this team can also be a resource to other players for such assistance as legal advice. Additionally, members of this team include staff who guide the game process.

Challenges:

- Introduce activities into the game from your field of expertise as you determine.
- Respond to inquires for assistance from other team players.
- Exercise a veto over some team actions if necessary to maintain game integrity in accordance with the objectives.
- Act as President of the United States.
- Resolve all situations and problems.

Money

Money serves several very important functions in this game, including:

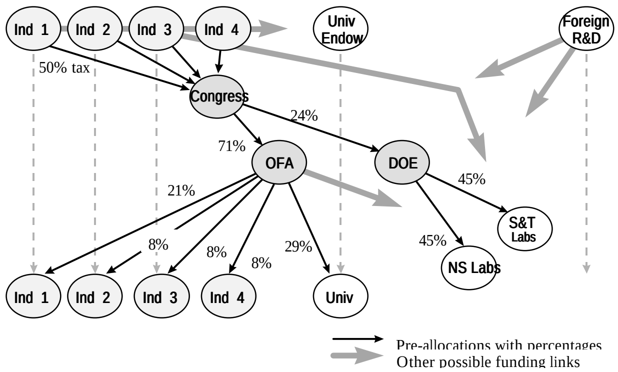

Figure A-1. Flow of money in the game.

- representing the scarcity of resources and the need to prioritize investments;
- approximating the relative influence of the different stakeholders;
- providing a method to treat the real risks involved in R&D investments;
- approximating the flow of money in the real world;
- helping to distinguish between customers (R&D funders) and suppliers (R&D performers);
- establishing a basis for negotiations, partnerships and joint ventures;
- providing an anchor to reality.

However, it is important that money not overly interfere with the creativity of the players, and the development of new strategies to meet the teams' challenges and objectives. Winning the game does not *necessarily* mean accumulating the most money. Winning is accomplishing the game objectives and the players' objectives, and translating the learning and experimentation into real-world solutions.

Based on our experience, we have introduced several simplifications into the distribution chain of funds by preallocating funds. However, all teams have the same prerogatives as they do in real life.

In this game, industry is assumed to also represent all workers, and hence is the ultimate source of most income in the game. Congress is assumed to levy a 50% tax on all industry income. In turn, Congress allocates its funding to the federal agencies (DOE, OFA), who in turn provide funding for the labs, universities, and industry. The

Table A-1. Primary funding sources ($M) (pretax).

Team	Fraction of National Expenditures and Source	Session 3 1998-1999	Session 4 2000-2001	Session 5 2002-2003
US Industry 1	0.42% of Industry R&D	699	671	645
US Industry 2	0.14% of Industry R&D	233	224	215
US Industry 3	0.14% of Industry R&D	233	224	215
US Industry 4	0.14% of Industry R&D	233	224	215
University R&D	0.75% of Endowments, etc.	103	100	98
Foreign R&D in US	0.50% of For. Cos. In U.S.	160	160	160
	Totals =	**1661**	**1603**	**1548**

Table A-2. Funding "food chain" - sources and recipients ($M).

Funding and Receiving Teams	Funds to:	Session 3 1998-1999	Session 4 2000-2001	Session 5 2002-2003
Congress taxes Industry	50% to Congress	699	672	645
Congress funds DOE	24% to DOE	168	161	155
Congress funds Other Agencies	71% to Other Federal Agencies (OFA)	496	477	458
Congress discretionary	5% to Congress	35	34	32
DOE funds Weapons Labs	45% to Weapons Labs	76	72	70
DOE funds Other Labs	45% to Other DOE Labs	76	72	70
DOE discretionary	10% to DOE	16	17	15
OFAs fund Industry	21% to Industry 1	104	100	96
"	8% to Industry 2	40	38	37
"	8% to Industry 3	40	38	37
"	8% to Industry 4	40	38	37
OFAs fund Universities	29% to Universities	144	138	133
OFAs discretionary	26% to OFA	128	125	118

assumed funding chain is shown in Figure A-1. The figure also shows that the teams may alter or redirect their spending and income with agreements executed during the game (both black and gray arrows). Funding teams can change assumptions over the course of the game by notifying the Control team. Changes are then implemented in the subsequent sessions. Table A-1 shows the six teams at the “top” of the food chain, and their projected income over the course of the game. Table A-2 shows the assumed percentage, source and dollar projections for the teams lower in the food chain, and how the agencies are assumed to distribute their funds. Congress must distribute all of its funds through its agencies.

Changes may also be made beyond the allocation table. For example, Congress may decide to reduce spending on entitlement programs and increase R&D (or vice versa); this will be allowed if the President (Control) concurs.

The final allocations (projected), i.e., the results of this food chain, are shown for session 3 in the section “Game Concept and Description.” Projections for sessions 4-5 can be easily calculated from Tables 1-2.

Rules of Play

Contracts:

Contracts or agreements can be carried out between any two or more teams. Contracts must describe an exchange of value for value. All contracts must use the standard form (see Figure A-2) and be legibly written. Agreement forms should be filled out from the top down. The 50% cost should be obtained from Control before final commitments are made. Team representatives should bring the written contract to the Control team for final approval; a member of the Control team must sign and date the agreement for it to be valid. If the success or failure of the contract is determined probabilistically, Control will perform the necessary calculations and report the results to the parties immediately. Success or failure will be determined by sampling from a normal distribution with the actual sum invested, just as was done for the Toolkit investments. For example, investing twice the median estimate will produce a base probability of success of 84.1%; superimposed on this probability is another uniform probability distribution that represents uncertainties and risks that are not necessarily reduced by larger investments.

Disputes:

All disputes will be resolved by the Control team, whose decisions are binding.

Lawsuits:

Lawsuits can be filed at any time by any team. An odd number (at least 3) of judges must hear the case. After both sides have presented their arguments, the judges decide by majority rule. Judges' decisions are final and binding. Litigants must appear before the judges at their scheduled times. If one litigant is one minute late, a judgment will be immediately rendered in favor of the litigant who is present. If both litigants are five minutes late, the case will be dismissed; the litigants will need to reschedule their court times.

Schedules, Appointments

It is essential that all players strictly follow the agenda and be on time for their appointments. Penalties can be assessed for players or teams that are late.

Toolkit Options

Investments in Toolkit options must be turned in before the deadline. Investment amounts should be legibly written on the Toolkit forms. Completed forms must be submitted to the Control team prior to the deadline. Players and teams cannot exceed their maximum total investments shown on the forms. Results of the investments will be announced and implemented into the play of the game. Only one opportunity is available for Toolkit investments.

Teams or players who wish to create **new options** must follow these steps:

- Write up option clearly;
- Discuss it with a designated member of the Control team; if accepted, Control will assign a median probability cost;
- Provide all investors with written copies of the new option, together with the amount they will invest, and the signature of the team facilitator;
- Bring option and investments to Control before deadline.

Marketing of new options to other teams is the responsibility of the initiating team. New technology investments outside the Toolkit follow a similar process.

Additional Information

Science, Technology, and Society
by Marshall Berman

Almost all human progress is a result of science and technology. Science is “systematic knowledge of the

Figure A-2. Prosperity Games™ agreement form.

TERMS AND CONDITIONS: ____

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EXPECTED RETURN ON INVESTMENT AND JUSTIFICATION: ______________________

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Facilitator Review: ____________________

50% Probability Cost: $________ ________________ ____________
Control Team Date/Time

APPROVALS AND FUND TRANSFERS

Team	Amount	Signature
US Congress	$ ________	________________
US Industry #1	$ ________	________________
US Industry #2	$ ________	________________
US Industry #3	$ ________	________________
US Industry #4	$ ________	________________

Team	Amount	Signature
DOE	$ ________	________________
Other Fed. Agncy	$ ________	________________
Universities	$ ________	________________
Weapons Labs	$ ________	________________
S&T Labs	$ ________	________________
Foreign Team	$ ________	________________

Prosperity Games

Investment was: ❒ Successful ❒ Unsuccessful

Approval by: ______________________________ ________ ______
Control Team Date Time

physical or material world gained through observation and experimentation." Technology is "the application of knowledge for practical ends." Without science and technology, humans would still live in gatherer societies, unable to hunt without tools, or cook and stay warm without fire. It is clear that science and technology are fundamental to human existence and progress.

The enormous improvements in the quality and duration of life in the last few centuries are results of science and technology (S&T). Despite this, some people have begun to question the need for S & T, the level of private and public support for it, and the impact of technology on the environment. Whereas S&T were once seen as public investments in economic and social progress, they are now seen by some as expenditures, as consumption of scarce resources no different from other social costs. Some even consider S&T as a potential menace in need of control and limitation.

Attacks on S&T expenditures and science itself have arisen out of a confluence of economic and social trends including: pressures to reduce government spending, corporate emphasis on rapid return on investments, international competition, poor science education, widespread public science and math illiteracy, and some extreme elements of certain societal movements such as multiculturalism, feminism, environmentalism, animal rights, alternative medicine, and social reconstructionism.[1] Although the vast majority of scientists and engineers have ignored these trends, that may no longer be possible.

Science education is declining or under direct attack. In 1914, science and math composed 16% of a typical college graduate's training; today, they make up less than 6%. New bills have been introduced into the Tennessee House and Senate that would again make it a crime to teach evolution.

The need for a stronger link among science, technology and society has been recognized by many in the science, political, and academic community. "Science, Technology and Society" (STS) is now a recognized major at Stanford University. Similar programs have been developed at MIT, Cornell, Vassar, Penn State, and in other countries (Canada, England, Norway, Sweden, Holland and Austria). The Stanford STS degree program (B.A. or B.S.) is "predicated on the belief that science and technology are two of the most potent forces for individual, societal, and global change in the contemporary era."

[1] E.g., see John Maddox, *Nature*, **368**, 185; (17 March 1994); Paul Gross and Norman Levitt, *Higher Superstition: The Academic Left and Its Quarrels with Science*, Johns Hopkins University Press, 1994; Richard Nicholson, *Science* **261,** 143, (9 July 1993); Gerald Holton, *Science and Anti-Science*, Cambridge, Mass., Harvard University Press, 1993.

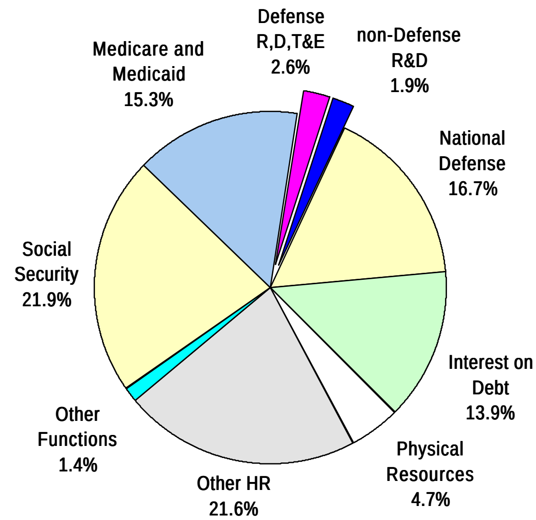

Figure A-3. US budget outlays - 1994.

It is intuitively obvious that S&T ultimately increase the quality of life and the standard of living of the population. However, quantification of this causal link is extremely difficult because of the multitude of other factors that influence macroeconomic measures and because of the time delays between innovation and availability of different technologies.

Moral support for the benefits of S&T does not directly translate into solutions of pragmatic questions: what level of support is appropriate; what fraction should be supported at public expense; what topics should be pursued; who among the S&T performers (universities, industry, national laboratories) should perform different types of R&D; what synergies are possible; where are efforts redundant; how should multidisciplinary high-risk research be funded and performed. In the US, answers to these questions can form the framework of a national science and technology delivery system. This Prosperity Game is intended to initiate an exploration of these questions. The ideas, problems and opportunities developed here can be converted into important actions to help support and use science and technology in the best interests of the country.

Figure A-3 shows the allocation of federal expenditures in 1994. Federal R&D expenditures for that year represented only 4.5% (about $67B) of the total, with 1.9% (about $28B) non-defense related. Social Security, Medicare and Medicaid and spending on other Human Resources accounted for 59% of outlays (about $860B).

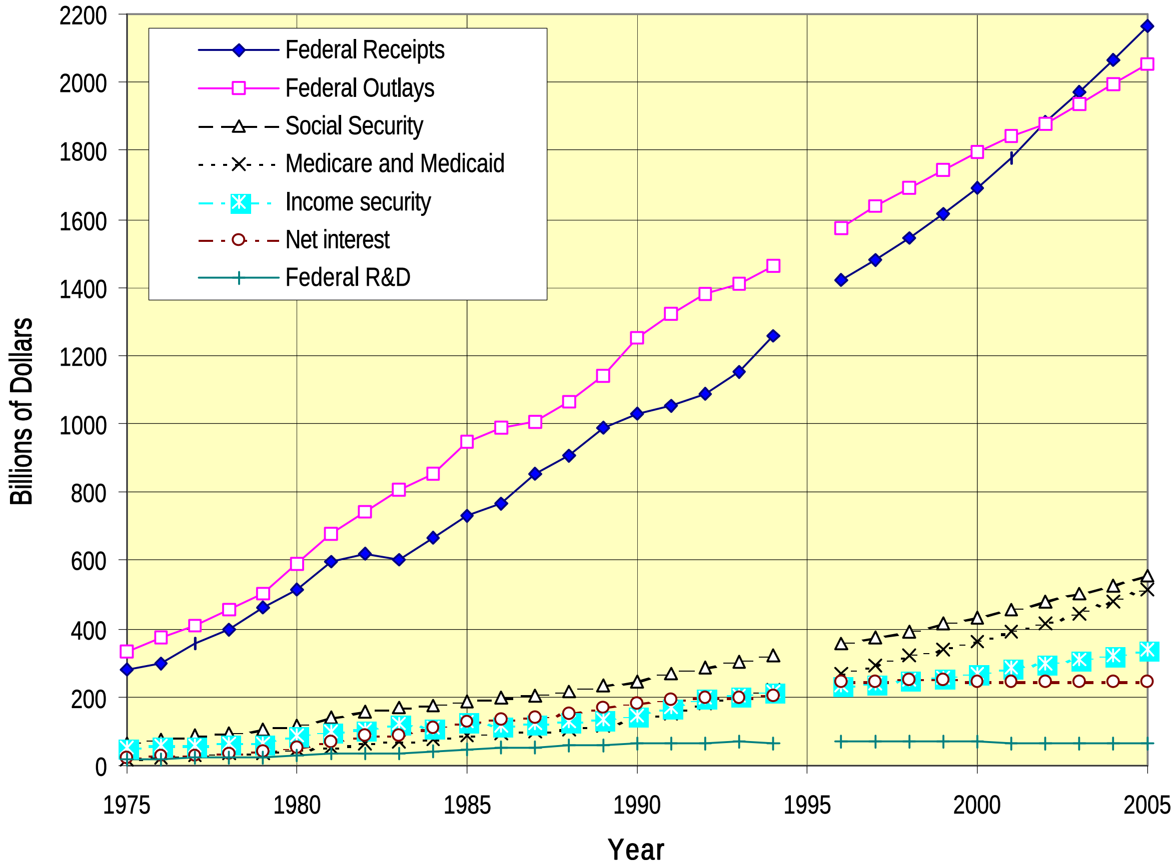

Figure A-4. Federal receipts and outlays (actual dollars).

Figure A-4 shows historical and projected data on federal receipts and outlays in actual dollars. The projections are from the President's 1997 budget proposal, estimated to be in balance by 2002.

Additional economic data and the basis for the funding allocations in this game are provided in the next section on R&D Economics: History and Projections.

R&D Economics: History and Projections

The money allocations in this game are based upon projections using the President's budget proposal for 1997[2], which calls for a balanced budget in 2001. Projections for other R&D spending, industry figures, and personal savings were based on historical data collected by the National Science Foundation[3] and the Bureau of Economic Analysis (US DOC)[4]. Although the data gathered from all sources was in dollars, we have converted all values to 'Constant 1996 dollars' to remove the effects of inflation from the game, and to highlight real growth rates (positive or negative) in spending. Some of the data are presented in Table A-3.

The **bolded** data in Table A-3 are from the 1997 budget proposal. Data for the DOE Labs and for federal R&D funds going to industry and universities are projected from the NSF data and trends in discretionary funds from the 1997 budget proposal. The other data are projections based on historical or projected data from the indicated source, scaled to the 1997 budget numbers if necessary. The final column in the table gives some indication as to the method used for projection. A percentage rate indicates an average, though not constant, growth rate from year to year.

[2] The Budget of the United States Government, Budget Supplement and Historical Tables, FY1997.
(http://www.doc.gov/BudgetFY97/index.html)

[3] National Patterns of R&D Resources, 1995 Data Update.
(http://www.nsf.gov/sbe/srs/s2195/start.html)

[4] National Income and Product Account Tables: 1959-95. US DOC. BEA.
(gopher://una.hh.lib.umich.edu:70/11/ebb)

Table A-3. Prosperity Game baseline economic projections in constant 1996 dollars ($B).

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Scale to:
GDP	**7336**	**7490**	**7659**	**7832**	**8002**	**8184**	**8364**	8548	8736	8928	
Real Growth (GDP)		2.10%	2.25%	2.26%	2.18%	2.27%	2.20%	2.20%	2.20%	2.20%	
Federal Receipts	**1427**	**1453**	**1492**	**1520**	**1551**	**1584**	**1619**	1653	1689	1725	2.2%
Federal Outlays	**1572**	**1589**	**1584**	**1579**	**1576**	**1576**	**1581**	1592	1603	1614	0.7%
Social Security	**348.1**	**354.5**	**362.4**	**369.4**	**376.9**	**384.5**	**392.3**	400.3	408.5	416.8	2.1%
Medicare/Medicaid	**269.8**	**284.7**	**296.4**	**305.4**	**313.6**	**325.5**	**336.3**	347.4	358.9	370.8	3.4%
Income Security	**228.3**	**230.0**	**231.5**	**233.0**	**236.4**	**234.3**	**238.4**	242.1	245.8	249.7	1.6%
Net Interest	**241.1**	**231.8**	**223.2**	**215.7**	**205.7**	**197.5**	**189.0**	181.1	173.5	166.3	-4.3%
Federal R&D	**68.5**	**67.2**	64.5	62.9	62.0	60.7	60.2	59.2	58.3	57.3	-1.7%
DOE Weapons Labs	3.3	3.2	3.1	3.0	2.9	2.8	2.7	2.6	2.5	2.4	FedR&D
DOE ER/EM Labs	2.8	2.7	2.6	2.5	2.5	2.4	2.3	2.3	2.2	2.1	FedR&D
To Industry [3]	20.5	20.1	19.7	19.3	18.9	18.5	18.2	17.8	17.4	17.1	FedR&D
To Universities [3]	12.8	12.4	12.1	11.8	11.5	11.1	10.7	10.4	10.1	9.8	FedR&D
DOD, non-R&D	228.6	215.8	207.1	202.7	202.1	198.9	200.4	198.9	197.3	195.8	-1.0%
DOE, non-R&D	10.9	10.5	9.5	8.3	7.0	7.1	6.8	7.1	6.9	6.7	-3.0%
Other Federal	177.1	194.7	189.7	181.3	171.9	167.6	158.0	156.1	153.9	150.7	
Federal Deficit	**-145.6**	**-136.2**	**-92.6**	**-59.2**	**-24.7**	**7.2**	**37.2**	61.0	85.6	110.8	
US Industry Gross Profits [4]	578.4	590.6	603.8	617.5	630.9	645.3	659.5	674.0	688.8	703.9	GDP
Net Profits [4]	355.1	362.6	370.7	379.1	387.4	396.2	404.9	413.8	422.9	432.2	GDP
Undistributed Profits [4]	133.0	135.8	138.8	142.0	145.1	148.4	151.6	155.0	158.4	161.9	GDP
Industry R&D (source) [3]	103.5	101.8	100.0	98.4	96.7	95.1	93.5	92.0	90.4	89.0	
US Companies	87.5	85.8	84.0	82.4	80.7	79.1	77.5	76.0	74.4	73.0	-2.0%
Foreign Companies	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	0.0%
University R&D (source) [3]	7.1	7.0	6.9	6.8	6.7	6.6	6.5	6.5	6.3	6.3	-1.8%
Personal Savings [4]	224.0	219.5	215.1	210.8	206.6	202.5	198.4	194.5	190.6	186.8	-2.0%

FedR&D and *GDP* indicate rough scaling to the changes in Federal R&D spending and the GDP, respectively.

Graphical representations of these projections, as well as historical data from 1975-1994, are given in four figures below. All are given in terms of Constant 1996$ to show real changes. The 1995 data have been omitted from the figures to highlight the shift from historical to projected data.

Figure A-5 shows that the President's proposed balanced budget is to be achieved primarily through spending cuts, but without substantially slowing the growth of Social Security or the Medicare and Medicaid programs. Much of the proposed spending cut (approximately 50%, based on comparison of the President's 1996 and 1997 budget proposals) is to be accomplished through reduction of 'Net interest.' Net interest projections are heavily tied to economic assumptions. The President's 1997 budget assumes that the interest rates that the government pays on Treasury bills and notes will decrease significantly over the next seven years, at rates that are less than those used in the 1996 budget by 0.4% to 1.4%, depending on the year. The only thing certain about these projections is their uncertainty.

Equally as uncertain are the budget projections for real growth in GDP and in the consumer price index (CPI) as shown in Figure A-6. While the projections for real growth are comparable to the 20-year average of 2.5 ±2.2%, those for inflation are significantly lower than the 20-year average of 5.3±2.6%; the inflation projections are heavily weighted by the very low inflation rates of the last few years. The history of GDP growth shows very large fluctuations that cannot be captured in future projections. Figure A-6 also shows that the fraction of GDP used for R&D has been decreasing for several years, and may drop below 2% by the year 2001.

Spending on R&D in the United States in real terms is also on the decline as shown in Figure A-7. With the pressure to balance the budget within seven years, it is not likely that real spending on R&D will increase or even keep pace with inflation. Industry is the largest user of R&D, using nearly all their own funds as well as 30% of Federal R&D funds.

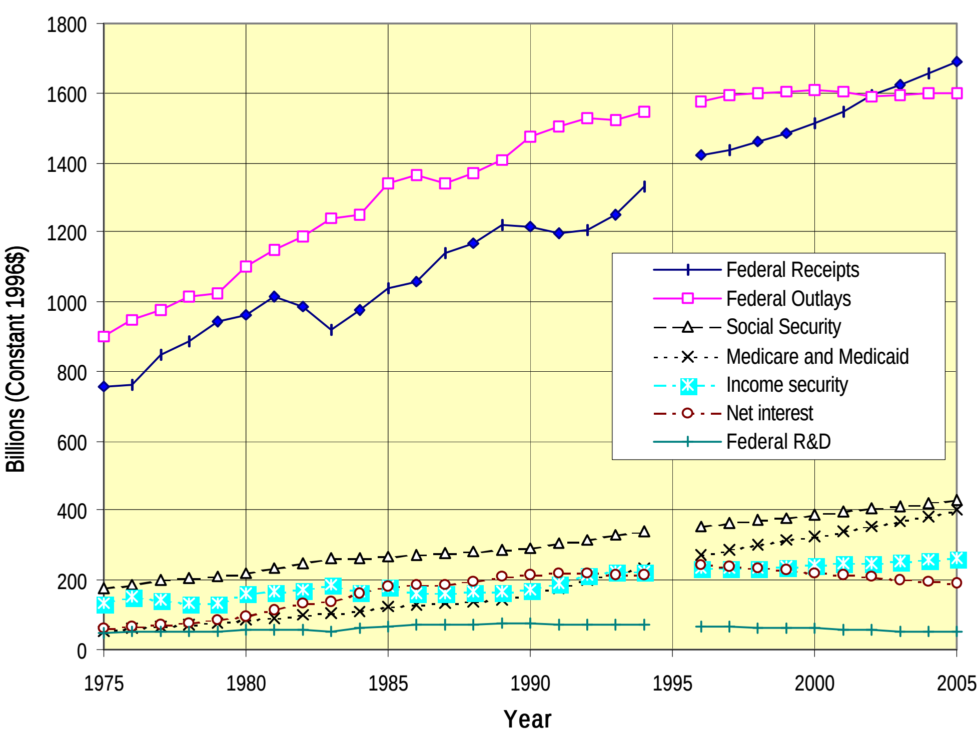

Figure A-5. Historical and projected federal receipts and spending.

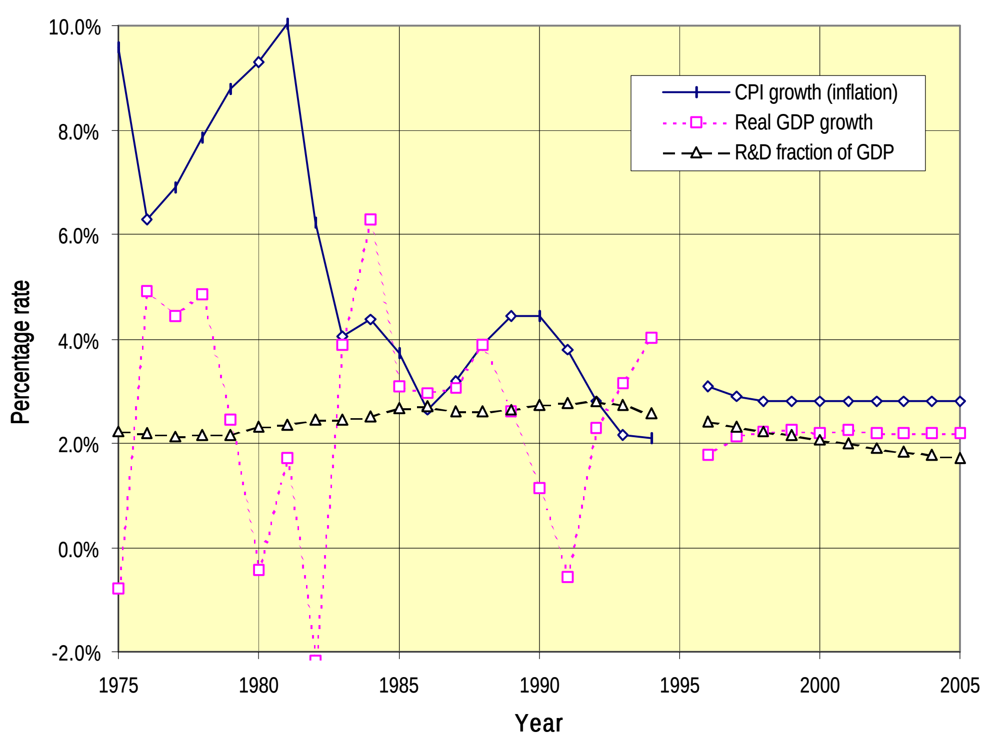

Figure A-6. Historical and projected growth, inflation, and R&D investment rates.

Industry typically sends only 1.5% of their R&D funds out-of-house, mostly to Universities. Universities have limited self-funding (endowments, state and local grants, non-profit funding) resources, but receive about 19% of Federal R&D funds. In total, Universities are currently spending nearly the same amount on R&D as are all Federal laboratories combined (all DOE, DOD, NIH, NASA, NIST, etc., labs). The DOE Weapons laboratories only spend 15% as much as universities spend on R&D.

GDP, industry figures, and personal savings are shown in Figure A-8. Industrial profits tumbled between 1979 and 1982, but have increased fairly steadily since that time. However, personal savings has remained relatively constant since 1975, with perhaps a slight downward trend, despite the increase in population and productivity over the same period. Thus, the personal savings rate has been decreasing in the US for many years.

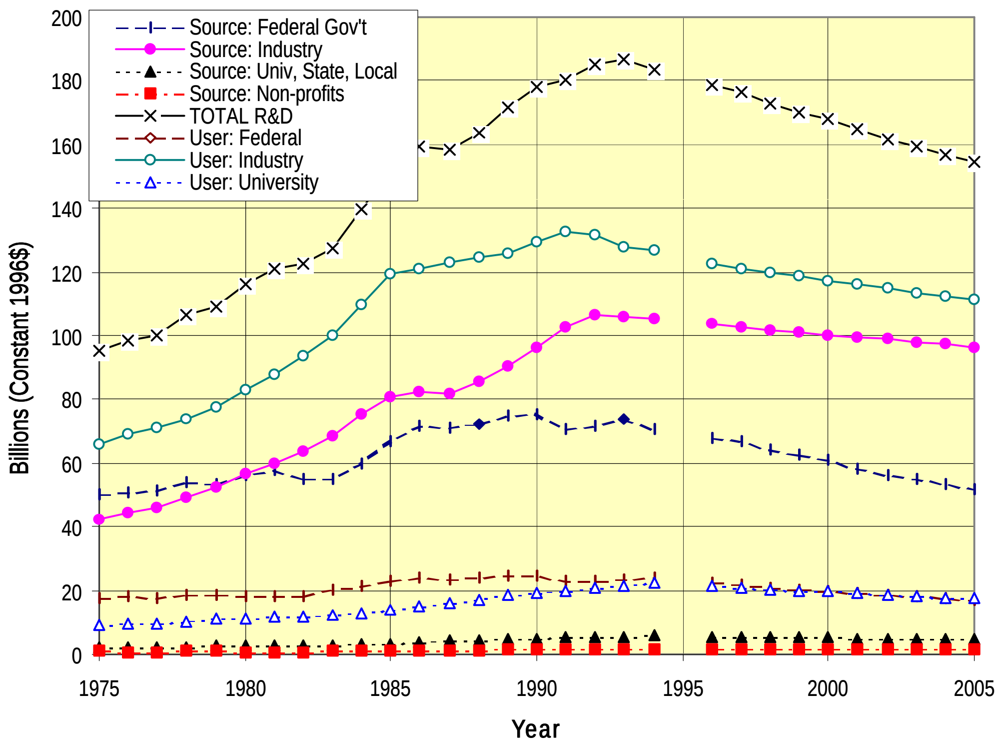

Figure A-7. Historical and projected US R&D sources and spending.

The initial money allocations in the game, as given in the 'Money' section of the appendix, have been determined in a way that allows all teams to have some power in the game, and to have money roughly equal to their relative influences in the R&D arena. Only R&D moneys have been initially allocated. Other moneys, such as US budget expenditures for Social Security, agency non-R&D budgets, etc., have not been allocated, since the purpose of this game is to focus on R&D.

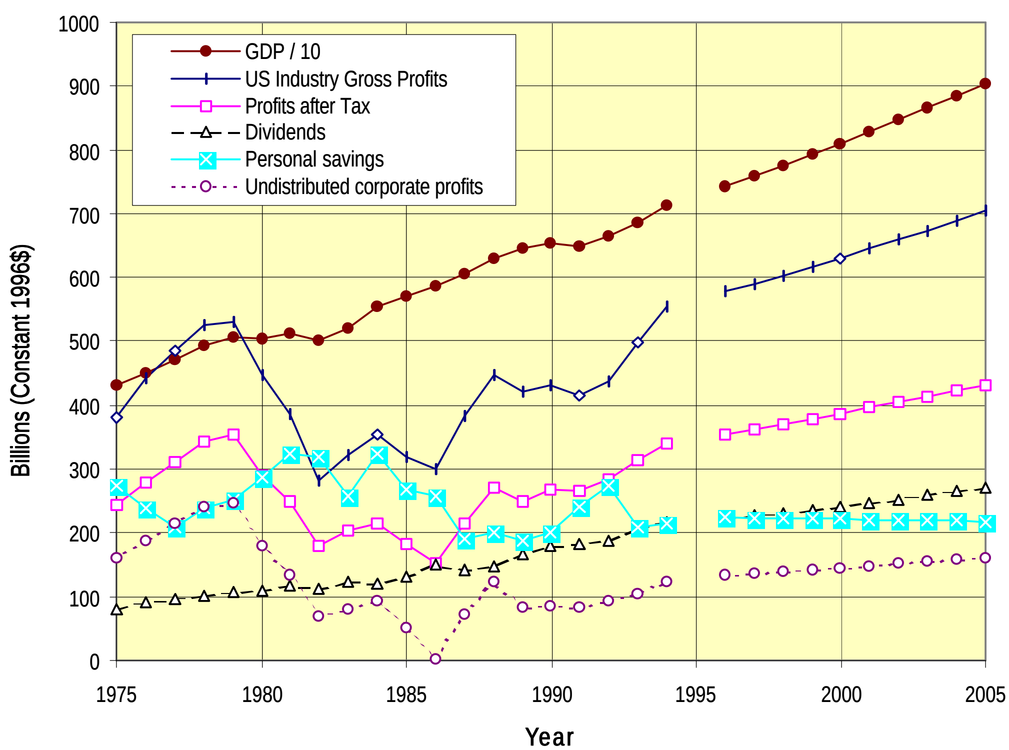

Figure A-8. Historical and projected US industry and personal savings.

Technology Innovation Legislation Highlights
prepared by the Federal Consortium (FLC) for Technology Transfer

Stevenson-Wydler Technology Innovation Act of 1980 (Public Law 96-480)

- Focused on dissemination of information.
- Required federal laboratories to take an active role in technical cooperation.
- Established Offices of Research and Technology Application at major federal laboratories.
- Established the Center for the Utilization of Federal Technology (in the National Technical Information Service).

Bayh-Dole Act of 1980 (Public Law 96-517)

- Permitted universities, not for profits, and small businesses to obtain title to inventions developed with governmental support.
- Allowed government-owned, government-operated (GOGO) laboratories to grant exclusive licenses to patents.

Small Business Innovation Development Act of 1982 (Public Law 97-219)

- Required agencies to provide special funds for small business R&D connected to the agencies' missions.

Cooperative Research Act of 1984 (Public Law 98-462)

- Eliminated treble damage aspect of antitrust concerns for companies wishing to pool research resources and engage in joint, precompetitive R&D.
- Resulted in Consortia: Semiconductor Research Corporation (SRC) and Microelectronics and Computer Technology Corporation (MCC), among others.

Trademark Clarification Act of 1984 (Public Law 98-620)

- Permitted decisions to be made at the laboratory level in government-owned, contractor-operated (GOCO) laboratories as to the awarding of licenses for patents.
- Permitted contractors to receive patent royalties for use in R&D, awards, or for education.
- Permitted private companies, regardless of size, to obtain exclusive licenses.
- Permitted laboratories run by universities and non-profit institutions to retain title to inventions within limitations.

Japanese Technical Literature Act of 1986 (Public Law 99-382)

- Improved the availability of Japanese science and engineering literature in the US

Federal Technology Transfer Act of 1986 (Public Law 99-502)

- Made technology transfer a responsibility of all federal laboratory scientists and engineers.
- Mandated that technology transfer responsibility be considered in laboratory employee performance evaluations.
- Established principle of royalty sharing for federal inventors (15% minimum) and set up a reward system for other innovators.
- Legislated a charter for Federal Laboratory Consortium for Technology Transfer and provided a funding mechanism for that organization to carry out its work.
- Provided specific requirements, incentives and authorities for the federal laboratories.
- Empowered each agency to give the director of GOGO laboratories authority to enter into cooperative R&D agreements and negotiate licensing agreements with streamlined headquarters review.
- Allowed laboratories to make advance agreements with large and small companies on title and license to inventions resulting from Cooperative R&D Agreements (CRADAS) with government laboratories.
- Allowed directors of GOGO laboratories to negotiate licensing agreements for inventions made at their laboratories.
- Provided for exchanging GOGO laboratory personnel, services, and equipment with their research partners.
- Made it possible to grant and waive rights to GOGO laboratory inventions and intellectual property.
- Allowed current and former federal employees to participate in commercial development, to the extent there is no conflict of interest.

Malcolm Baldrige National Quality Improvement Act of 1987 (Public Law 100-107)

- Established categories and criteria for the Malcolm Baldrige National Quality Award.

Executive Orders 12591 and 12618 (1987): Facilitating Access to Science and Technology

- Promoted access to science and technology.

Omnibus Trade and Competitiveness Act of 1988 (Public Law 100-418)

- Placed emphasis on the need for public/private cooperation on assuring full use of results of research.
- Established centers for transferring manufacturing technology.
- Established Industrial Extension Services within states and an information clearinghouse on successful state and local technology programs.
- Changed the name of the National Bureau of Standards to the National Institute of Standards and Technology and broadened its technology transfer role.
- Extended royalty payment requirements to non-government employees of federal laboratories.
- Authorized Training Technology Transfer centers administered by the Department of Education.

National Institute of Standards and Technology Authorization Act for FY 1989 (Public Law 100-519)

- Established a Technology Administration within the Department of Commerce.
- Permitted contractual consideration for rights to intellectual property other than patents in CRADAs.
- Included software development contributors eligible for awards.
- Clarified the rights of guest worker inventors regarding royalties.

Water Resources Development Act of 1988 (Public Law 100-676)

- Authorized Army Corps of Engineers laboratories and research centers to enter into cooperative research and development agreements.
- Allowed the Corps to fund up to 50% of the cost of the cooperative project.

National Competitiveness Technology Transfer Act of 1989 (Public Law 101-189) (included as Section 3131 et seq. of DOD Authorization Act for FY 1990)

- Granted GOCO federal laboratories opportunities to enter into CRADAs and other activities with universities and private industry, in essentially the same ways as highlighted under the Federal Technology Transfer Act of 1986.
- Allowed information and innovations brought into, and created through, CRADAs to be protected from disclosure.
- Provided a technology transfer mission for the nuclear weapons laboratories.

Defense Authorization Act for FY 1991 (Public Law 101-510)

- Established model programs for national defense laboratories to demonstrate successful relationships between federal government, state and local governments, and small business.
- Provided for a federal laboratory to enter into a contract or memorandum of understanding with a partnership intermediary to perform services related to cooperative or joint activities with small business.
- Provided for development and implementation of a National Defense Manufacturing Technology Plan.

Intermodal Surface Transportation Efficiency Act of 1991 (Public Law 102-240)

- Authorized the Department of Transportation to provide not more than 50% of the cost of CRADAs for highway research and development.
- Encouraged innovative solutions to highway problems and stimulated the marketing of new technologies on a cost shared basis of more than 50% if there is substantial public interest or benefit.

American Technology Preeminence Act of 1991 (Public Law 102-245)

- Extended FLC mandate, removed FLC responsibility for conducting a grant program, and required the inclusion of the results of an independent annual audit in the FLC Annual Report to Congress and the President.
- Included intellectual property as potential contributions under CRADAs.
- Required the Secretary of Commerce to report on the advisability of authorizing a new form of CRADA that permits federal contributions of funds.
- Allowed laboratory directors to give excess equipment to educational institutions and nonprofit organizations as a gift.

Small Business Technology Transfer Act of 1992 (Public Law 102-564)

- Established a three-year pilot program, the Small Business Technology Transfer (STTR) program, at DOD, DOE, HHS, NASA, and NSF.

- Directed the Small Business Administration (SBA) to oversee and coordinate the implementation of the STTR program.
- Designed the STTR similar to the Small Business Innovation Research (SBIR) program.
- Required each of the five agencies to fund cooperative R&D projects involving a small company and a researcher at a university, federally-funded research and development center, or nonprofit research institution.

National Department of Defense Authorization Act for 1993 (Public Law 102-25)

- Facilitated and encouraged technology transfer to small businesses.

National Defense Authorization Act for FY 1993 (Public Law 102-484)

- Extended the streamlining of small business technology transfer procedures for non-federal laboratory contractors.
- Directed DOE to issue guidelines to facilitate technology transfer to small businesses.
- Extended the potential for CRADAs to some DOD-funded Federally Funded Research and Development Centers (FFRDCs) not owned by the government.

National Department of Defense Authorization Act for 1994 (Public Law 103-160)

- Broadened the definition of a laboratory to include weapons production facilities of the DOE.

National Technology Transfer and Advancement Act (H.R. 2196, 1995) Signed March 7, 1996

- Simplifies negotiations regarding intellectual property rights arising from CRADAs. Federal labs will ensure to their private-sector CRADA partners "the option to choose an exclusive license for a pre-negotiated field of use for any … invention made in whole or in part by a laboratory employee under the agreement." The lab has the right to "reasonable compensation when appropriate."

Prosperity Games Background

A Prosperity Game is a new type of forum for simulating and exploring complex issues in a variety of areas including economics, politics, sociology, environment, education, research, health care, etc. The issues can be examined from a variety of perspectives ranging from a global, macroeconomic and geopolitical viewpoint down to the details of customer/supplier/market interactions in specific industries.

Prosperity Games are an outgrowth of move/countermove and seminar war games. They are executive-level interactive simulations that encourage creative problem solving and decision-making, and explore the possible consequences of those decisions in a variety of economic, political and social arenas. The simulations are high-level exercises of discretion, judgment, planning and negotiating skills, not computer games. They explore the challenges and opportunities faced by businesses, government, laboratories, universities and the public.

Thirteen previous Prosperity Games have explored environmental issues, economic competitiveness in electronics manufacturing and information technology, university business education, the business case for diversity, the DOE labs, and biomedical technologies (see Table A-4).

Game Theory

In mathematics, game theory is the study of strategic aspects of situations of conflict and cooperation. "Game Theory approaches conflicts by asking a question as old as games themselves: How do people make 'optimal' choices when these are contingent on what other people do?" [5] Game theory originated with the mathematician John von Neumann as early as 1928. The collaboration of von Neumann on theory and Oskar Morgenstern on applications to economic questions led to the seminal book *The Theory of Games and Economic Behavior* that first appeared in 1944, and was later revised in 1947 and 1953. Game theory is an approach to developing the best strategies in areas such as economics and war to beat a competitor or enemy. [Of course, one possible strategy is to convert an enemy into an ally, or a competitor into a partner!]

A game is defined by a set of rules that specify the players, their desired goals, allowed interactions, and a method of assessing outcomes. There can be one or more goals with different levels of importance. The players adopt strategies, and the interactions of the "moves" based on those strategies lead to outcomes which may or may not be consistent with the players' goals. Complex games involve look-ahead strategies that address the different possible moves that an opponent could make. It is important to try to understand an opponent's goals in order to maximize the probability of a favorable outcome. Games can be sequential, with player interaction allowed between moves.

[5] From Steven J. Brams, "Theory of Moves," *American Scientist*, **81**, 562-570, November-December 1993.

Table A-4. Thirteen previous Prosperity Games™ have been conducted.

Game	Sponsors
1. Sandia prototype	Sandia
2. Electronics Industries Association Board of Governors, Palm Springs, CA, January 20-21, 1994	EIA
3. American Electronics Association, Wash. DC, March 8-9, 1994	AEA
4. Advanced Manufacturing Day, Albuquerque, NM, May 17, 1994	Sandia
5. National Electronics Manufacturing Initiative Prototype, Albuquerque, NM, June 9-10, 1994	Sandia
6. National Electronics Manufacturing Initiative Pr ototype, Mt. Weatherall, VA, Sept. 7-9, 1994	NEMI, DARPA, EIA, AEA, Sandia
7. Environmental Game Prototype, Albuquerque, NM, February 6, 1995	Sandia, Silicon Valley Env. Partnership, LLNL, et al.
8. Environmental Prosperity Game, San Ramon, CA, March 29-31, 1995	Sandia, SVEP, Alameda Econ. Dev. Advisory Board, Bay Area Econ. Forum
9. University Game, Anderson Schools of Management, UNM, Albuquerque, NM, April 4 - May 2, 1995	Sandia, Anderson Schools of Management (UNM)
10. Diversity and DOE Labs Game, Albuquerque, NM, May 24-25, 1995	Sandia (4000)
11. Biomedical Technology Game Prototype, Albuquerque, NM, Sept. 22, 1995	Sandia (9400)
12. Biomedical Technology Prosperity Game, Albuquerque, NM, November 1-3, 1995	Sandia (9400), DARPA, The Koop Foundation, Inc.
13. Future of the DOE Labs Game Prototype, Albuquerque, NM, March 21-22, 1996	Sandia, LANL, LLNL, ORNL, Lockheed-Martin, University of California

Appendix B: List of Players and Staff

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Appendix C: Game Schedule

Monday, May 6, 1996

4:30 pm Participant registration and badging; collect materials.

5:00 pm Players gather in Conference Center; get acquainted with team members. “Hello” process; go to assigned tables.

5:30 pm Welcome: Deborah Wince-Smith, Donald M. Kerr, Milton Klein

6:00 pm Prosperity Game briefing/overview with questions and answers; polling
(Marshall Berman -- Game Director)

7:00 pm Dinner with your team members.

8:00 pm Formal meeting adjourned. Private team meetings and discussions may begin.

Tuesday, May 7, 1996

7:30 am Breakfast Buffet

SESSION 1 - May, 1996:

8:00 am Facilitators lead teams in initial assignments:
All teams: Set ground rules for deliberation, decision-making, etc. Review the team challenges defined in this Handbook. Modify and complete the challenges for your team. Define the different roles appropriate to your team and which players will represent each role. Develop game, team and personal objectives and strategies to meet your challenges. Begin to implement those strategies. Prepare Toolkit Investments. Make appointments with other teams to begin preliminary discussions.

10:30 am Break

SESSION 2 - January 1, 1997:

10:45 am Introduction to Session 2.
Plan Toolkit investments; partner with other teams.

11:50 am End of Session 2. ***Complete all Toolkit investments and submit only your own team’s options to Control team. No further Toolkit investments are allowed after 11:50 am.***

11:55 am Radio news broadcast.

12:00 Lunch
Luncheon Speaker, C. Paul Robinson, Sandia National Laboratories

SESSION 3 - January 1, 1998:

1:00 pm Successful Toolkit investments are announced and implemented.
Introduction to Session 3.

1:30 pm New money distributed. Continue deliberations and negotiations.

2:55 pm Radio news broadcast.

3:00 pm Break

SESSION 4 - January 1, 2000:

3:30 pm *Staff updates the world.* Successful technologies and policies that have been negotiated among the teams are announced and implemented into the game.
Teams assess status and progress; realign strategies as needed.

4:00 pm New money distributed. Continue deliberations and negotiations.

5:30 pm Teams select Ambassadors to National R&D Summit Meeting. Submit names to Control Team. Provide one topic for the Summit Meeting. End of day's activities

Wednesday, May 8, 1996

7:30 am Continental Breakfast

8:00 am Announcements. Introduction to Summit Meeting. Selection of topics and discussion.

8:30 am NATIONAL R&D SUMMIT MEETING

10:00 am Radio news broadcast.

10:05 am Break

SESSION 5 - January 1, 2002:

10:30 am *Staff updates the world.* Successful technologies and policies that have been negotiated among the teams are announced and implemented into the game.
Teams assess status and progress; realign strategies as needed.

10:45 am New money distributed. Continue deliberations and negotiations.

12:00 Active play ceases.
Radio news broadcast.

12:05 pm Lunch
Luncheon Speaker

SESSION 6 - January 1, 2004:

1:00 pm Teams digest game results, document best ideas, plan for follow-on activities, get volunteers to champion follow-ons.

2:00 pm Final radio news broadcast.

2:05 pm Play ceases. Teams select spokesperson; prepare final presentations. Vote on self-assessments.

3:15 pm Team debriefings and self-assessments - no more than 5 minutes each; group assessment by Innovator.
Challenges
Strategies
Successes
Failures

4:30 pm Wrap up; final polling; fill out evaluation forms.

5:00 pm Game adjourned.

Appendix D: Details of Team Play

Team Summary

Each team's investments and agreements were reviewed on the basis of available documentation including the actual agreements, game play records, staff meeting notes and reports, and the team presentations. The consistency and completeness of these records varied, resulting in some subjectivity in the observations documented herein. Team-by-team evaluations follow later in this section. Although the agreements were evaluated on their own in order to look for trends (see the Technology and Policy Initiatives sections of this report), an important part of this process requires an evaluation on a team basis. It is in this way that "out-of-the-box" thinking might be recognized for further consideration in follow-on activities by the game sponsors. For team comparison purposes, then, the following metrics were considered:

1. percent of all agreements originated by team (how creative was the team)
2. percent of team's investments spent on team's agreements (did the team believe in itself, or was it looking for something else?)
3. percent of other teams' (i.e., raised) funds spent on own team's agreements (did other teams believe in a team's agreements?)
4. percent of game funds spent on team's agreements (were the team's agreements important to the game as a whole?)
5. number of funded agreements team partnered in as a percent of those available (another measure of belief in partnering)
6. median number of participants in funded agreements team partnered in compared to the total number of teams (another measure of belief in partnering)
7. average size of the team's investments (possible measure of desire to partner)
8. median risk index of the team's investments (an assessment of capital invested as a function of success probability)
9. relative sophistication used in planning team's agreements (e.g., were investments made with due forethought?)

It needs to be stressed that these metrics do not indicate who "won" the game. As stated during the in-briefing for the game, who won is a subjective call on a team-by-team basis by the team's players and whether or not they felt that they met their objectives.

The first four metrics in the list above deal with agreements from the perspective of the team that originated and "sold" the idea. The numerical answers are arrived at by analyses of the raw agreements data. The results of these analyses are provided in Table D-1.

The next two metrics, numbers 5 and 6, are based on funded agreements data (i.e., studies and no-funds agreements are not considered here) without regard to the originator or the actual amount of funds involved. All of the partnering data for these agreements are provided in Table D-2. The information is broken down by success or failure and by Toolkit or post-Toolkit sessions. Both the total number of agreements (metric 5) and average partnering (related to metric 6) can be determined from the information in this table. In order to make team-to-team

Table D-1. Agreement Analyses by Originating Team (Metrics 1-4).

	US Congress	*Industry 1 (IT/AMfg)*	*Industry 2 (E/E)*	*Industry 3 (LS/AMat)*	*Industry 4 (NS/CJ)*	*US DOE*	*US Other Agencies*	*Universities*	*DOE NS Labs*	*DOE S&T Labs*	*Foreign Team*
% of agreements originating	23%	9%	16%	4%	6%	1%	7%	4%	14%	7%	9%
% of own funds spent on o.a.	24%	29%	39%	30%	51%	7%	11%	41%	43%	20%	49%
% total money raised for o.a.	0%	15%	17%	11%	3%	0%	1%	11%	23%	13%	5%
% of game funds spent on o.a.	1%	14%	13%	9%	6%	0%	1%	10%	13%	7%	12%

comparisons regarding tendencies toward higher partnering frequencies (and not just number of agreements), total R&D agreement distributions were evaluated for each team as a function of the number of parties in each agreement. The results are plotted in Figure D-1. As can be seen, all teams behaved in much the same way (e.g., similar deviations and medians; average median of 5.4), except for the National Security and Criminal Justice Industry Team that had a considerably higher median (8), and the DOE Team with a lower than average median (3.5). The high and low results for the NS/CJ and DOE teams could not be attributed to risk reduction measures, team strategy, or any other investment decisions. Values for metrics 5 and 6 and related information are provided in Table D-3.

Metric seven, the average size of a team's investment, is shown in Figure D-2. Note the strong trend among the teams to make larger investments given more money to invest with. Plentiful resources did not encourage teams to implement complex strategies that would have required more agreements. Only the NS/CJ industry team played significantly different from the general trend, although the reasons why are not obvious (this team partnered on agreements with more participants and spent more on these agreements, but did not have a lower risk profile as might otherwise be expected as discussed below).

In order to evaluate team tendencies to invest in higher probability-of-success ventures, team expenditures were evaluated against total agreement funding levels as a function of the assigned 50% probability-of-success value, metric 8. For the purposes of this comparison, the ratio of an agreement's assigned 50% probability-of-success value to its actual funding level is defined to be its risk index (higher index, higher risk of failure). Investments by team and risk index were plotted with the results shown in Figure D-3. Five teams (Congress, DOE, OFA, Universities, and Foreign Countries) made Toolkit investments where the probability of success was less than 50% (shown in Figure D-3 by the data points lying above a risk index of one), perhaps thinking that additional funds were going to be raised before the submission deadline. All of these high-risk investments failed (funding in two of these agreements was even too low to "start the work" (roll the "dice")); no team submitted any high-risk agreements in following sessions. The other noticeable thing in Figure D-3 is that the team trends are roughly the same (similar standard deviation), but with a spread in the medians. The calculated median risk index values are provided in Table D-4 by team. For reference, the median risk index for all investments was 0.59. It is interesting to note that the highest risk takers were Congress and the Universities Team, while the industry teams were among the lowest risk takers.

The last metric is an attempt to evaluate the execution of team strategic plans in agreements. It is also the most subjective. All available documentation was evaluated in an attempt to understand what team strategies were and how the agreements they entered into fit within these plans. Summaries of these evaluations are included in the individual team write-ups below. The results for each evaluation have been gathered together in Table D-5. The percentages given are estimates of how much of a team's expenditures (or number of agreements for the Congressional team in order to include their laws in the result) was spent within any one strategic complexity level. Note that no instances of *Impetus Futuro* behavior were noted. Finally, an overall weighted score was generated for each team based on the premise that higher strategic level is better, with the score given in percent of the maximum possible value (4).

As a means to help digest these various technology R&D-related metrics, all of them except number 7 (for which there was no easy way to normalize the result) have been plotted in Figure D-4 as a fractional score. Again, these metrics or scores do not represent winners or losers, but were used as a tool to locate interesting trends or game plays (e.g., identification of interests by most teams in computing significantly beyond that expected).

Table D-2. Technology R&D Agreement Partnering Data

	1 lone wolf	*2 partners*	*3 partners*	*4 partners*	*5 partners*	*6 partners*	*7 partners*	*8 partners*	*9 partners*	*10 partners*	*TOTAL*
TOOLKIT: Unsuccessful											
US Congress	2	1	1								**4**
IT/AMfg industry											**0**
E/E industry			1								**1**
LS/AMat industry	1										**1**
NS/CJ industry											**0**
US Dept of Energy	2	2									**4**
Other Federal Agencies		1									**1**
Universities	1										**1**
National Security Labs		2	1								**3**
Civilian S&T Labs											**0**
Foreign Countries	1										**1**
no. of agreements	**7**	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**11**
TOOLKIT: Successful											
US Congress			2		1		1				**4**
IT/AMfg industry			1					1			**2**
E/E industry			2		1		1	1			**5**
LS/AMat industry			1	1			1				**3**
NS/CJ industry		1		1							**2**
US Dept of Energy		1	1				1	1			**4**
Other Federal Agencies								1			**1**
Universities			1	1	1		1	1			**5**
National Security Labs					1		1	1			**3**
Civilian S&T Labs			1	1			1	1			**4**
Foreign Countries					1			1			**2**
no. of agreements	**0**	**1**	**3**	**1**	**1**	**0**	**1**	**1**	**0**	**0**	**8**
no. of toolkit agreements	**7**	**4**	**4**	**1**	**1**	**0**	**1**	**1**	**0**	**0**	**19**
POST-TOOLKIT: Unsuccessful											
US Congress											**0**
IT/AMfg industry		1	1		1			1			**4**
E/E industry					1			1			**2**
LS/AMat industry								1			**1**
NS/CJ industry								1			**1**
US Dept of Energy											**0**
Other Federal Agencies					1			1			**2**
Universities											**0**
National Security Labs			1					1			**2**
Civilian S&T Labs		1	1		1			1			**4**
Foreign Countries					1			1			**2**
no. of agreements	**0**	**1**	**1**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**4**
POST-TOOLKIT: Successful											
US Congress					1	3	1	1	1	2	**9**
IT/AMfg industry		1	2	7	2	5	2	1	1	3	**24**
E/E industry	2	1	1	3	1	3	2		1	3	**17**
LS/AMat industry			1	2	2	3	2			3	**13**
NS/CJ industry		1			1	2		1	1	3	**9**
US Dept of Energy				1		2		1		1	**5**
Other Federal Agencies		1	1	5	1	3	2	1	1	3	**18**
Universities			3	5	1	2	1	1	1	3	**17**
National Security Labs		1	3	3		2	2	1	1	3	**16**
Civilian S&T Labs			2	2		3	2	1	1	3	**14**
Foreign Countries	3	1	5	4	1	2			1	3	**20**
no. of agreements	**5**	**3**	**6**	**8**	**2**	**5**	**2**	**1**	**1**	**3**	**36**
no. of post-t'kit agreements	**5**	**4**	**7**	**8**	**3**	**5**	**2**	**2**	**1**	**3**	**40**
total no. of R&D agreements	**12**	**8**	**11**	**9**	**4**	**5**	**3**	**3**	**1**	**3**	**59**

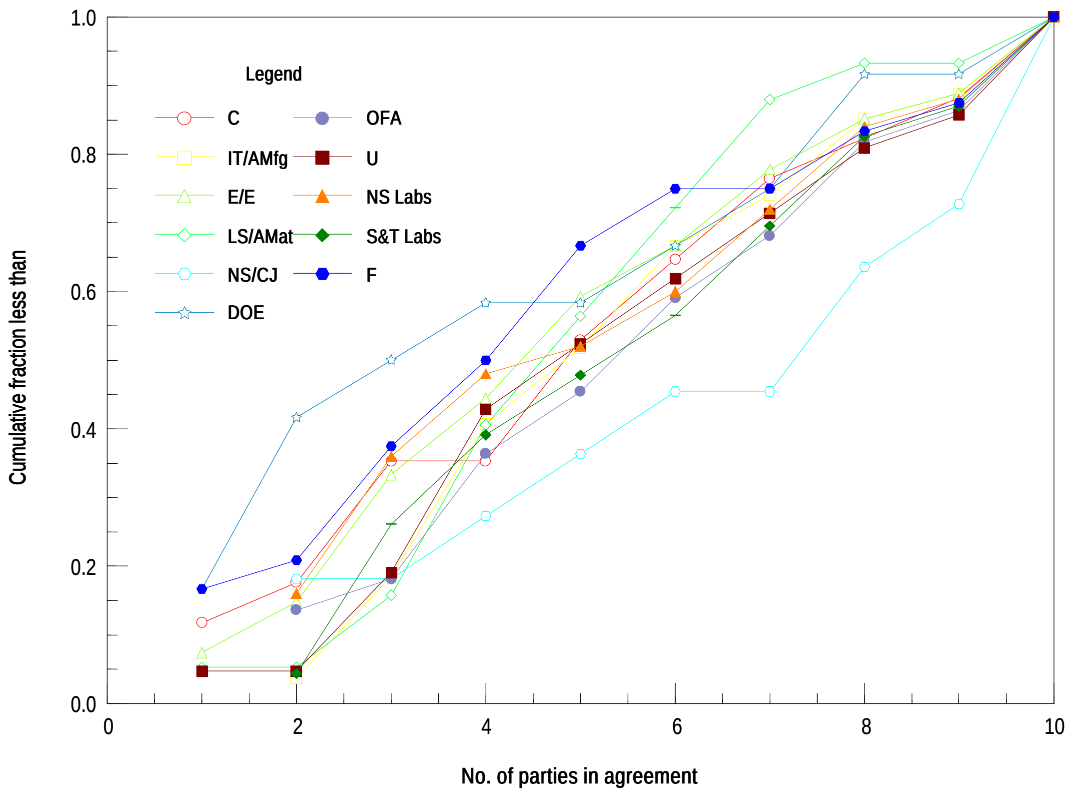


Figure D-1. Partnering frequency trends by team

Table D-3. Team Results for Metrics 5 and 6.

	Congress	*IT/AMfg*	*E/E*	*LS/AMat*	*NS/CJ*	*DOE*	*OFA*	*Universities*	*NS Labs*	*S&T Labs*	*Foreign*
Metric 5: no. of agreements	17	27	27	19	11	12	22	21	25	23	24
% of all agreements	29%	46%	46%	32%	19%	20%	37%	36%	42%	39%	41%
average no. of parties	5.4	5.7	5.2	5.8	6.7	4.5	5.9	5.8	5.4	5.9	4.9
Metric 6: median no. of parties	5.0	5.0	5.0	6.0	8.0	3.5	6.0	5.0	5.0	6.0	4.5
median as % of # of teams	45%	45%	45%	55%	73%	32%	55%	45%	45%	55%	41%

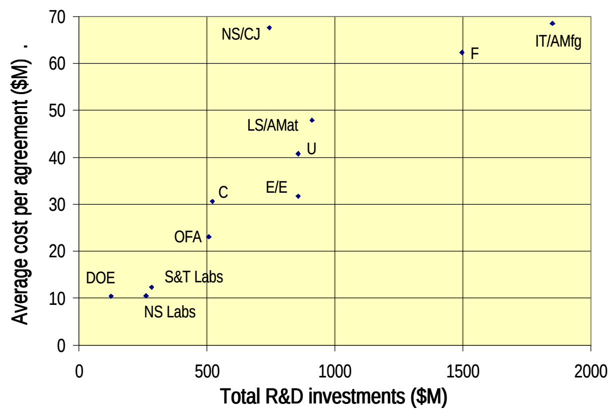


Figure D-2. Average investment size by team (metric 7)

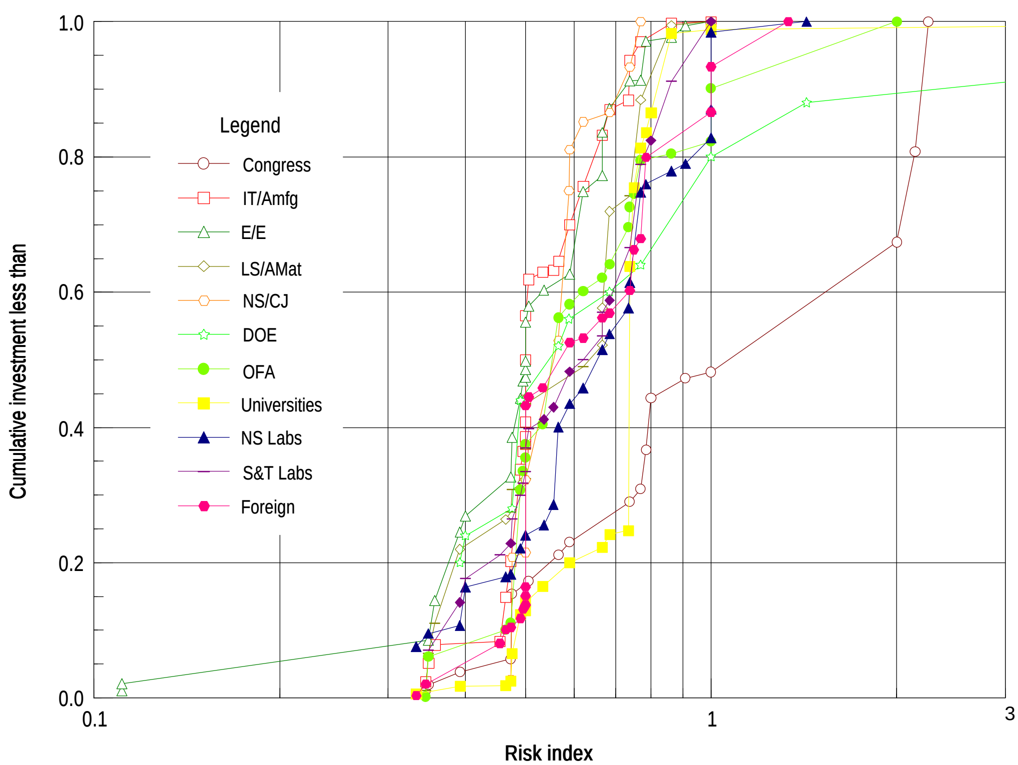


Figure D-3. Trends in investment risk by team.

Table D-4. Median risk index by team (metric 8).

	US Congress	IT/AMfg	E/E	LS/AMat	NS/CJ	US DOE	OFA	Universities	NS Labs	S&T Labs	Foreign
Risk index	0.74	0.50	0.50	0.50	0.59	0.64	0.61	0.67	0.62	0.54	0.52

Table D-5. Team R&D Investment Strategies (Metric 9).

Team	Carpe Diem (W=1)	Partes Pro Toto (W=2)	Crescit Eundo (W=3)	Impetus Futuro (W=4)	weighted score
US Congress	56%	35%	9%		45%
IT&AM industry	79%	9%	12%		33%
E/E industry	30%	70%			43%
LS&AM industry	55%	45%			36%
NS&CJ industry	18%	40%	42%		56%
US DOE	16%	84%			46%
US OFA	26%	74%			43%
Universities	78%	22%			31%
DOE NS Labs	42%	14%	44%		51%
DOE S&T Labs	72%	28%			32%
Foreign Countries	18%	82%			46%

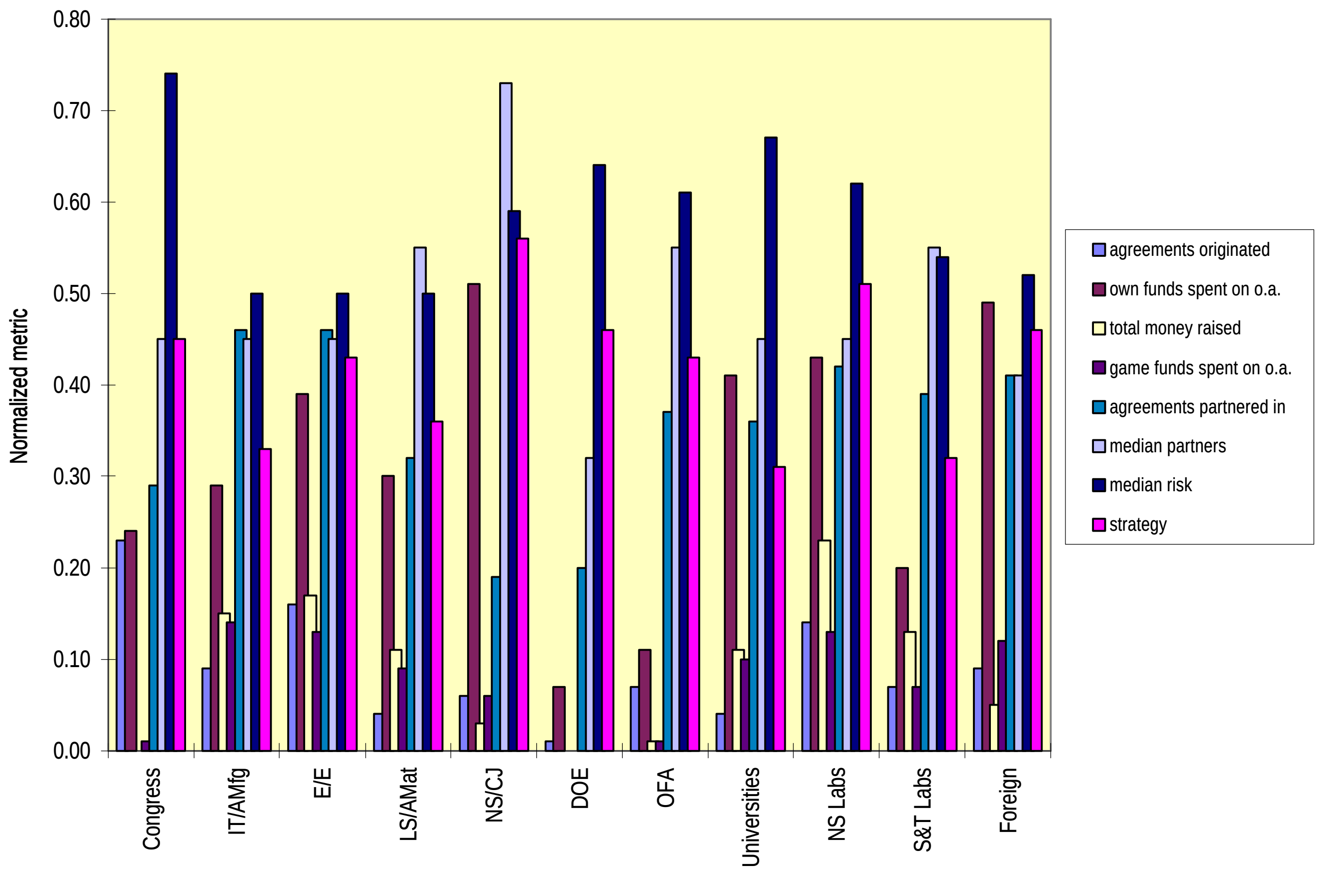


Figure D-4. Graphical presentation of normalized team metrics

Individual Team Play

US Congress

The Congressional team successfully incorporated both majority and minority views in development of their specific goals. These goals were:

1. To Improve the Quality of Life for All Americans
2. To Maintain Our Quantitative Superiority in National Defense
3. To Balance the Federal Budget by the Year 2002
4. To Ensure that the United States is Globally Competitive

In support of these goals, detailed strategies were developed. Most of the team effort was then focused on drafting legislation to implement the stated goals and strategies. No documented, specific plans concerning technology investments or reallocation of “appropriated” funds were evident. The Congressional team did draft one approved technology agreement that developed software for diagnosis, epidemiological studies, remote consultation and diagnosis, and health management with a focus on reducing health care costs and improving patient services (T37; this was T20 with the added focus). Interestingly, Congress did not fund this agreement, but instead funded the original agreement at a level of $40M.

Of the $550M given to Congress for the Toolkit session, $315M (57%) was spent on technology options and 18% ($100M) on policy; $135M remained uncommitted and was thus lost. Congress also spent an additional $106M on technology agreements during sessions 3, 4 and 5 (received $110M; other $4M probably not spent before end of game).

All of the technology investments made directly by Congress could be considered supportive of Goal No. 1, which was broad in scope. Indeed, since Congress has such a broad charter in representing the people, investment in almost any technology might be considered within Congressional purview. In order to better assess team behavior, expenditures were compared to the actual federal budget (certain assumptions had to be made to split the federal R&D budget into the game technology areas). The overall, final distribution of Congressional funds across the four principle technology areas is somewhat different from the actual federal budget, with health and national security being lower and information technology and energy higher. This trend in Congressional R&D spending is illustrated in Figure D-5. The difference may reflect the interests of the players themselves, rather than the real Congress. Analysis of the agreements funded by Congress can be used to clarify their specific interests within the two areas in which they spent more than expected. In the information arena, Congress supported two agreements with $80M in the areas of information surety and the National Computing and Networking Initiative. Under the energy category, Congress supported four initiatives in transportation and transportation fuels with another $80M. The interest in information technology may be a reflection of the national attention currently being paid to this area. The interest in transportation is interesting in that, during the summit, the Congressional representative stated a position indicating that high energy costs for transportation were a misperception. Technology investments all appeared to be *carpe diem*.

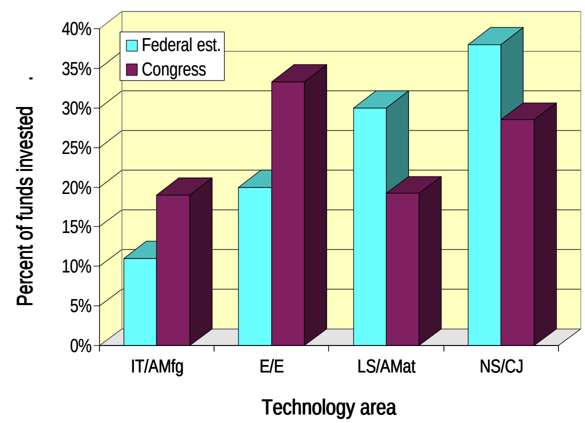


Figure D-5. Congressional team technology investments vs. estimated federal expenditures.

The $100M spent by Congress during the Toolkit session on policy went toward a single initiative: the Nunn-Domenici Tax Reform Bill (P49), which was a new Toolkit item that had been drafted by the Congressional Team. This bill did not pass during the Toolkit session due to insufficient support (only $200M was raised out of a minimum of $225M required to even “roll the dice”). Congress also drafted a second Toolkit option, P44, that would have placed a precondition on all international agreements that all intellectual property rights would be honored and that a parity in tariffs would exist. Congress did not succeed in raising any support for this agreement (not even of its own funds).

During the post-Toolkit phase of the game, the Congressional team was very active in drafting legislation to improve the US position in a globally competitive market. This included: passage of the American Economic Competitiveness Act (L5), that merged many separate efforts into one department in order to coordinate US economic development activities; support for R&D (amended anti-trust laws to permit joint and coordinated

R&D, L7; R&D tax credits, L10); intellectual property rights reform (L11); and enabled overseas sales of drugs if approved by a foreign regulatory agency (L14). Congressional efforts to reduce the federal budget deficit also took many paths. Deficit reduction efforts included: improvements in the efficiency of the federal labs (eliminate redundancies in the federal lab system (L10); restructure DOE (L3); formed a lab consolidation and closure commission (L12); and provided for the sale of excess DOE facilities (L13)); placed a restriction in the growth of entitlement spending (L7); sold rights to oil reserves in the ANWAR field (L8); and completely restructured the US tax system to be based on consumption rather than income (L1 and L2). Support for national defense needs was limited to two acts: the Anti-terrorism Act (L6) that provided for use of the DOE National Labs in combating terrorism; and the Critical Industry Preservation (CIP) Act (L4), that was a resolution or Congressional Statement for the Record originating with the OFA team that stated that it was the intent of Congress to maintain those industries that were critical to the national defense regardless of their competitive stance in the global market. All of these laws passed by the Congressional team can be considered to be in direct support of the goals established at the start of the game.

Whereas the sixteen R&D agreements Congress entered into were considered to represent *Carpe Diem* planning, the sixteen policy agreements it participated in generally demonstrated a higher level of strategy. Of these, only the CIP Act (that was brought to Congress by the OFA team) and the ANWAR sales (in part a response to the increased funding required to deal with the “China” situation) could be considered *Carpe Diem*. The remaining policy agreements are at least at a *Partes Pro Toto* level of thinking, although efforts in dealing with the DOE lab system (L3, L12, L13) could be considered to be *Crescit Eundo* strategy.

Industry One (Information Technology and Advanced Manufacturing; IT/AMfg)

The IT/AMfg team developed a goal for the game of reducing the cost of computing and communication to enable increased global consumption. To effect this goal the team chose to invest in the deployment of initiatives that heavily utilized IT; this was expected to translate into increased production that would in turn reduce costs, and thus increase IT use. The stated initiatives were:

1. telemedicine
2. smart buildings
3. high-speed mass transit
4. desalination plants
5. intelligent transportation

In the field of health or telemedicine (allowing initiative one to have a broad interpretation), the IT/AMfg team devoted 11% of their resources in support of three of the five funded agreements in this technology found in the game. Interestingly, this team did not support any Toolkits in this field, nor did they originate the primary telemedicine R&D agreement (N1). The one agreement the team did originate in this area (N34) was not clearly related to telemedicine except for marketing (certification and licensing); the R&D effort itself built on computer modeling and simulation work to develop a cure for an emerging third-world viral disease.

For initiative 2, the team developed a successful agreement (N9) in which they invested 6% ($110M) of their available resources. Three other teams put up an additional $70M in support of this technology. No follow-on effort was documented.

Initiatives 3 and 5 were linked serially in the strategic planning of the IT/AMfg team. Both of these transportation efforts (N18 & N33) were successfully planned and executed by IT/AMfg, with the team investing a total of $220M (12%). The team attracted an additional $319M that was spent in support of these efforts by teaming with other players (nine other teams participated in one or both of these agreements). The IT/AMfg team also participated in a related agreement sponsored by E/E (N27) in the amount of $100M. The total transportation investments related to initiatives 3 and 5 thus amounted to 18% of the IT/AMfg team’s available resources.

Operational deployment of desalination plants was listed as one of the initiatives to coordinate and support by the IT/AMfg team (although it was not clear how this related to IT or AM in any significant way that required R&D). The team did, in fact, provide $60M (3%) toward this effort very late in the game (N22), although it did not apparently originate the agreement (the documentation is sketchy, and this agreement may have been planned in some joint manner with the foreign team). Neither did the team support the related and successful clean water Toolkit option (T17).

In summary from an R&D perspective, the IT/AMfg team contributed 39% of the $1775M in funds earmarked for technology development to eight agreements related to stated initiatives in support of their goal. Four of these eight agreements were originated by them. An additional 35% of this team’s funds went toward eight agreements that clearly had an IT or AM component; two of these agreements were drafted by the IT/AMfg team: advanced information surety (N15), and a low-cost Internet access/personal computing device (N24). The remaining team funds spent in technology development went toward support of eight agreements in the energy, environment, advanced materials, and national security technology areas (N8, N31, N23, N5, N28, N36, N12, N17). The majority of all the investments undertaken by the IT/AMfg team appeared to be driven by a *carpe diem* approach, with only the efforts in the transportation field (12% as a serial or *crescit eundo* strategy), smart buildings, and desalination (9% *partes pro toto*) displaying specific advanced planning.

In contrast, the IT/AMfg team only used 4% of its expenditures in policy related agreements by participating in three non-R&D ("policy") agreements during the game. One was a contribution of $50M toward passage of a Toolkit item (P30) that gave a permanent tax credit for all R&D work sponsored by US companies. $20M was given to support a Universities team educational project (N14) that was geared to provide students with global leadership, teaming and communication skills. Finally, $5M went to support a NS Labs initiated effort to set up an Industry Technical Information Network (N35). These three agreements are all considered to be *carpe diem* in nature, although they are not of sufficient size to influence the overall team's planning score.

Industry Two (Energy and Environment; E/E)

Early in the game the E/E team developed it's objective to provide reasonably priced, environmentally sound energy for society. To support this objective, a prioritized list of nineteen specific technologies to pursue was developed.

1. Improved portable energy sources
2. Enhanced in-situ remediation for hydrocarbons, heavy metals, and radioactive material
3. Improved fossil plant (coal and gas) efficiency and environmental results
4. Advanced nuclear cycles
5. High-temperature materials
6. Deep-water oil/gas technology
7. Transportation systems simulation and modeling
8. Smart buildings
9. Next-generation vehicle
10. Superconducting Magnetic Energy Devices (SMEDs)
11. Improved electrical transmission with power electronics
12. Superconducting power systems
13. Electrical distribution automation systems
14. Renewables
15. Improved seismic processing
16. Closing the nuclear fuel cycle
17. Fusion
18. Enhanced hydrocarbon recovery systems
19. Low cost, rapidly processed structural composites

Only the last item, "Low cost, rapidly processed structural composites" was not clearly in line with the team's game objective. These technologies were eventually grouped into three categories of high (fund), medium (intent was to fund only if high category was adequately funded), and low priority (do not fund).

In the high-priority category (items 1-6), the E/E team funded ten agreements using 44% of available resources, eight of which the team originated (N3, N6, N7, N8, N10, N11, N19, N20); only item 3 remained unfunded at some level-of-effort. Fifteen percent of the team's funds went to priority 2 items (items 7-8), where the team funded 3 agreements, one of which it originated (N27). Another 10% of the E/E team's funds went toward four agreements that could be categorized as priority three, one of which they also initiated (N28). Thus 68% of E/E's (I2) resources were expended in pre-planned technology R&D areas. Although none of these agreements were explicitly planned to build on one another (i.e., *crescit eundo*; N19 was simply a repeat of N8), they did show a high level of *partes pro toto* planning compared to the other teams. Of the remaining funds, 2/3 (20% of total) were spent on four clearly E/E related technologies, while the rest went toward five agreements in the information technology ($54M toward T5 and N24), life sciences, and advanced materials areas; thus 32% of funds were spent in a *carpe diem* fashion.

The ten R&D agreements that the E/E team drafted made this team the most prolific in the technology R&D arena (only exceeded by the Congressional team's laws). In comparison, the second most prolific team was IT/AMfg with six agreements. The E/E team also did very well in selling their agreements to other teams, and managed to raise $2 for every $1 they invested (total of $950M invested in team 2 agreements). This degree of leveraging was only exceeded by the two labs teams. E/E team agreements also tied up 12.5% of the game funds; only IT/AMfg had better total-dollar participation in their agreements by engaging 14.1% of the game funds (although this was due to the fact that IT/AMfg was the richest team and made 50% of the total contributions). The E/E team actually raised more money than any other team except for the Weapons (National Security) Labs. Finally, even though they were not the richest team, the E/E players participated in more technology agreements than any other team, for a total of 26 (IT/AMfg contributed to 24).

The E/E Team only contributed money to one non-R&D ("policy") agreement during the game: it spent $50M (6% of all expenditures) on passage of a Toolkit item (P30) that gave a permanent tax credit for R&D. However, prior to investing in P30, the E/E Team drafted a no-cost agreement (P30A) that was approved by the Control Team that changed the wording of P30 to set the tax credit to 10% for all R&D work sponsored by US companies including that outsourced to universities and national labs. This pair of agreements is considered to represent a higher level of planning, and increases the team's *partes pro toto* activity to 70%.

Industry Three (Life Sciences and Advanced Materials; LS/AMat)

Five major thrust areas were defined by the LS/AMat team for the purposes of focusing its efforts in the game. The focus was oriented toward advanced materials due to the interests and experiences of the team members. These thrust areas were:

1. new structural materials for buildings, roads, bridges, and aerospace applications
2. high-energy batteries
3. superconducting wire (for power and mass transit applications)
4. recyclable/reusable materials and program, especially for polymers, reinforced composites; national distribution system for scrap materials
5. biomedical materials (artificial pancreas and injectable materials)

If a broad interpretation to thrust area 1 is taken, the LS/AMat team expended 27% of their resources in two related agreements. The first was $130M spent in support of the unsuccessful Toolkit T24 (smart materials). The second was $100M provided in support of N5, an agreement drafted by this team that developed materials for a hybrid vehicle; this effort explicitly built on both the R&D coming from Toolkit T11 (gasoline fuel efficiency increased by 10%), and the product resulting from the successful T5 (virtual workplace).

Although advanced batteries would appear to be second priority on LS/AMat's list, the two agreements in this area (N8/N19) were initiated by E/E. The LS/AMat team funded this activity with 6% of their resources ($50M), and at that level were only sponsors of 16% of the initial, unsuccessful effort (N8); they did not contribute to the follow-on, successful effort (N19).

The third thrust of the LS/AMat team received 15% ($130M) of the available resources. This was spent in its entirety on N23, an agreement drafted by the team that developed a new class of room-temperature superconducting materials. The fourth and fifth thrusts of the LS/AMat team received no apparent attention beyond the initial strategy session.

Twenty-one percent ($175M) of the LS/AMat team resources were expended on seven agreements (N1, N10, N17, N18, N26, N28, N34) in areas that were at least implicitly within the group's charter. One of these agreements was sponsored by this team (N1), where they spent $40M to successfully develop a system and standards for telemedicine, diagnosis, and health management.

Thirty-one percent ($255M) of the LS/AMat team resources were spent on a variety of agreements that were all originated by other teams, and that had no obvious life sciences or advanced materials R&D component sufficient to attract this level of funding. These included: T18; N15; N24; N27; N29; and N36 (IT efforts N15 & N24 received $55M). It must be assumed that such sponsorship was more in line with simply obtaining a high ROI rather than investment in appropriate R&D.

Overall, LS/AMat spent 69% ($585M) of its budget on LS or AM activities. Of this, $270M was allocated to the three agreements (N1, N5, N23) the team initiated. Four agreements (T24, N5, N8, N23) that consumed $410M (49%) in team funds could be considered to have been executed in a *partes pro toto* fashion. The remaining $430M (51%) was evidently spent as the occasion arose (i.e., *carpe diem*).

In addition to its R&D activity, the LS/AMat Team spent $70M (8% of its total spending) on successful policy options. $40M went to P30, that gave a %10 permanent tax credit for industry R&D, and $30M went toward P46, that gave a 25% tax credit for industry R&D that was performed under formally traceable partnerships with universities or federal labs. These investments are considered opportunistic in nature, and result in an increase in the teams *carpe diem* score to 55%.

Industry Four (National Security and Criminal Justice; NS/CJ)

Unlike her sister teams, the NS/CJ team evidently did not develop a specific set of technologies that should be pursued during the game. Most of the strategic planning actually focused on policy, and concerns to maximize ROI and obtain exclusive rights on all agreements. The statements regarding technology were broad and included:

1. Identify technologies strategic to our business and invest in those technologies.
2. Identify important and break-through technologies our industry needs for the future; leverage their development while retaining some intellectual property rights.

3. Invest in technologies to bring products to market.

Toolkit discussions included technology options to focus on: tagging; encryption; mine detection; motion sensors; proximity sensors; material sensors; biosensors; data information processing; and mobile power supplies. Well into session 3, team records indicate that some limited discussions on "potential businesses" took place, which listed: land mines, prisoner tracking, and a safety tracking system. The land mines option was evidently not pursued any further. The prisoner and "safety" tracking system ideas were evidently an outgrowth or re-expression of the various sensor options. The desire to invest in information technology and power supplies led the NS/CJ team to support the computing/networking (N2) and advanced batteries (N8) initiatives in sessions 3 & 4. This team also supported the internal security effort (N12) in session 4 as it was clearly in their business line, although it was not one of their selected technologies to pursue. Eventually (session 5) the tracking interests were put into the only agreement originating with this team, N21, which successfully developed a suite of low-cost sensors. The NS/CJ team put 18% ($80M) of their resources into funding this successful agreement, along with another $20M received from IT/AMfg. Along the information processing line, NS/CJ also supported N24 in session 5, which developed a low-cost internet access/PDA. In all, this team utilized 72% ($319M) of its funds in the pursuit of technologies related to NS or CJ, or otherwise laid out in its business planning.

Upon further evaluation of the N21 agreement, it was stated by NS/CJ that the sensors developed were to be combined with other industry advances in power sources, information/telecommunications, security, and software development tools. Interpreting this to be the basis for their investments in N2, N8, and N12, this sequence of agreements totaling $314M (71%) has the flavor of a *crescit eundo* strategy.

No investments were made in manufacturing technologies (item 3), although it was not clear anyway how this was specifically related to the NS or CJ roles this team was playing.

The remaining team funds ($125M or 28%) were spent on four agreements (N23, N26, N27, N33) that were not directly related to the stated team strategy. Since these all came at the end of the game, it can be reasonably assumed that they were simply spending their money in a *carpe diem* fashion on anything they could get reasonable ROI or exclusive rights agreements on.

In summary, 72% of the NS/CJ team R&D funds were expended along related business lines. Although documentation is sparse, it appears that most of this, 71%, was spent with a *crescit eundo* strategy, and the initial three investment decisions made effective use of other team initiatives to get into the position they wanted. The remaining funds were spent in a purely *carpe diem* strategy on anything that looked good as time was running out. The team was not prolific in its writing (one agreement) or teaming (nine agreements). Half of the team's technology funds and 2/3 of the agreements it participated in were consummated late in the last active game session.

In contrast to the other three industry teams who were only marginally interested in influencing policy, the NS/CJ team expended 40% of its total resources in Toolkit policy options that it drafted. $165M was spent on an agreement (P45) that required DOE, DOD, and DOC labs to spend not less than 25% of their R&D budgets on programs with the private sector (joint funding required). Another $135M went toward P46 that provided for a 25% tax credit for industry R&D that was performed under formally traceable partnerships with universities or federal labs. Both of these agreements were repealed by Congress (L1) early in the next game session. This team also drafted a third agreement (S4) during the Toolkit session with the NS Labs Team regarding Toolkit investment distributions (a no-cost agreement that was not executed due to escape provisions that were exercised). Policy investments by this team were considered to represent a *partes pro toto* strategy.

US Department of Energy (DOE)

During the planning session, the DOE team determined that their main theme was National Security. This theme was then further developed into mission areas that can be summarized as:

1. National Security: maintain stockpile leadership while reducing lab activity to a minimum core competency level. Technology should be driven to modeling, simulation, and a virtual laboratory. Also emphasize non-proliferation work. Provide DOD with DOE technologies.
2. Energy: work in "everything that converts, develops, or supplies energy." Strategy to include development of a portfolio of new and alternative energy sources. Also includes mine cleanup.
3. Environment: work in cleanup (develop enhanced and new technologies) and in developing sustainable technologies. Also develop more realistic, risk-based standards [regulations].
4. Basic science: as required to provided the necessary underlying foundation to the other mission areas. Also seen as important for industrial sustainability and competitive advantage.

To further these technology goals, the DOE team spent less R&D money by itself ($100M) than any other team. Toolkit expenditures amounted to $75M, while post-Toolkit spending was limited to $25M. However, it should be pointed out that the $25M spent by the DOE team was only part of total post-Toolkit receipts of $135M ($45M of this was the DOE team discretionary funds, $10M was ROI, while the remaining $80M was from $40M held back from each lab team during the last game session). A total of $59M of these funds were eventually spent by the S&T Labs team and $16M by the NS Labs team on R&D agreements after disbursement by the DOE team. The DOE team was the only federal group that attempted to alter the default game allocations, or to send discretionary funds to teams further down on the funding chain. However, there were complaints about the DOE team taking too long to effect these disbursements.

In support of the national security mission, DOE's focus was on information technologies in support of the modeling, simulation, and virtual lab thrust. In this category, the DOE team invested 45% ($45M) of its discretionary resources in agreements T3, T5, and N2 in what could be considered a *partes pro toto* strategy. An additional $10M was spent on the internal security effort (N12) since it clearly involved the NS labs, but this was more an opportunistic investment (*carpe diem*), rather than an outgrowth of specific planning.

Initially following a *partes pro toto* approach in the energy arena, DOE invested $5M in trying to develop alternative efficient and clean fuels for vehicles (T12). However, with no other sponsors this program quickly died. Also in the energy arena, the DOE team spent $5M in a successful bid to increase the efficiency of gasoline use in vehicles by 10% (T11); although this was certainly within the broad scope of the DOE's energy charter, it was not part of the stated strategic intent and must be considered as *carpe diem* behavior.

Keeping explicity within the environmental thrusts outlined in the planning session (*partes pro toto* approach), DOE allocated $25M towards developing risk/cost based regulations (T18) and $5M toward developing new environmental remediation technologies (N11).

The last investment made by the DOE team was to put up $5M towards development of a room-temperature superconductor (N23). This expenditure was within the realm of the Basic Science mission in support of the energy program, although it was clearly a target of opportunity (*carpe diem*) rather than a specific, planned investment.

In summary, all of the DOE R&D investments were in keeping with the general objectives or strategies outlined in the planning session. Eighty percent of the investments were in keeping with specific plans geared towards supporting an overarching mission and could thus be considered part of a *partes pro toto* strategy. Remaining investments appeared to be strictly *carpe diem* in nature. A breakout of these investments by technology area is provided in Figure D-6 alongside an estimated split of the DOE FY1993 budget. The DOE team only participated in nine agreements, although this may be considered to be largely due to the small amount of funds available. The team did not draft any of the agreements approved or funded during the game.

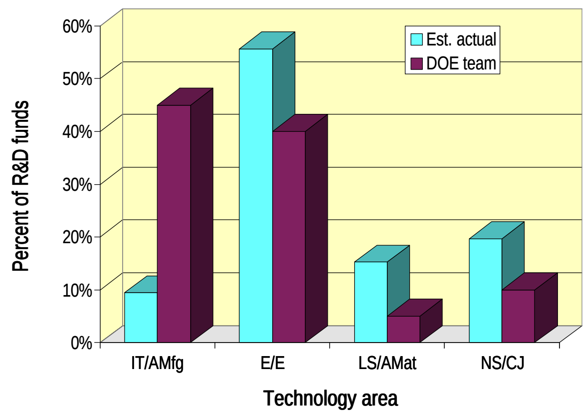


Figure D-6. DOE team game funding allocations vs. estimated partition of FY1993 budget.

DOE spent an additional $25M (20% of total directly spent) in pursuit of policy options it considered to be important. Of this, $10M went to develop a system of labs (P4); however, this amount fell far short of that needed to successfully pursue such a course of action (50% success level required $100M), and no partners were forthcoming. Another $15M went toward partnering initiatives: $5M to P45 requiring 25% of labs budget be spent with the private sector; and $10M toward a 100% tax credit for R&D funded by industry at universities or federal labs (P48; unsuccessful). Since these Toolkit investments are consistent with the "Laboratory Guiding Principles" established by the team during its strategic planning, they would appear to represent *partes pro toto* thinking. During the post-Toolkit sessions, DOE drafted a funding agreement (S4) that would have sent $9M to the S&T labs to perform a study that identified areas of importance to the E/E industry; no buy in is recorded on the part of the S&T Team, and the agreement is considered to be unfilled. The DOE team also approved a no-cost agreement (S3) presented by the NS Labs Team wherein the DOE agreed to eliminate overhead charges on partnering agreements and to allow incremental cost recovery.

Other Federal Agencies (OFA)

The OFA team decided from the outset that they would represent all federal agencies other than the DOE. A page long list of important technologies to pursue quickly grew out of this assumption. However, the team was able to reduce this to a priority listing that included:

1. Secure, robust and widely applied information infrastructure
2. Deterrence and defense of non-classical attacks
3. Sustain and improve the environment
4. Education/enhanced employability
5. Global projection of American power & influence

Within these priorities, the OFA team spent 74% of their total funds (the OFA and foreign teams were the only ones that did not invest in policy). Investments in priorities one, two, and four demonstrated committed, continuing (connective) support that is probably indicative of a *partes pro toto* strategy. Priority one investments were $125M (25%) that was tagged for work in computing technology (T5 & N2). Another $130M (27%) was expended in support for internal security technology efforts (T33 & N12). Finally, $38M (8%) was spent on priority four activities in order to develop educational technologies (N4 & N16). In contrast, priorities three and five were written so broadly compared to the related investments, and the investments were themselves singular with no pre- or post-activities, indicating that the OFA team was following a *carpe diem* strategy with these efforts. The environmental effort was in the form of $30M in support for agreement N36 that developed remediation technologies for use in inner-city brown-field sites. The priority five effort involved one of two funded agreements that the OFA team wrote: the design of a highly accurate, low-yield, deep-earth penetrating nuclear weapon (N13). The OFA team used $40M of its funds and a $10M contribution from the NS labs to successfully execute this agreement (DOE and Congress authorized the work, but provided no additional funds).

The other 26% ($129M) of the OFA team funds were spent on 13 agreements that spanned many interests across all four game technology groupings. All of these fit within the broad charter of the OFA team. Two agreements (N9 & N29) within the IT/AM area were supported with contributions of $30M. Forty-nine million dollars were earmarked for five energy and environmental projects (N8, N18, N27, N28, N33). Another five projects in the LS/AM arena received a total of $41M from the OFA team. The last of these *carpe diem* agreements was for the second funded agreement that was originated by the OFA team ("Study" No. 1, or S1). In this agreement, the OFA sent $9M to the NS labs (who contributed $11M of their own assets) to conduct a study of industrial technologies that could be applied to meet classified needs of the defense, intelligence and justice communities.

A third agreement was drafted by the OFA team, and approved by Control, but received no funding. This was Toolkit option T36 that was to launch a major new program to ensure the integrity and security of the global information infrastructure and telecommunications system.

In order to assess any unusual team focus in its spending interests, it was desirable to find some way to assess team performance relative to its constituency. Assuming NASA (space) and NSF interests are evenly divided between the different game technology areas other than defense, and that DOD R&D spending includes expenditures in IT/AM (10%), E/E (10%), and LS/AM (10%), a rough projection on the OFA spending distribution can be made based on the current federal budget (less DOE). The OFA team expenditures within the technology areas can then be compared to look for differences to address. This comparison is shown in Figure D-7. From this graph and the actual investments made it can be determined that the OFA team had a strong propensity to spend resources on information technology at the expense of health related R&D. This is perhaps not unexpected given that the team had no member from NIH with a life science interest. It may also reflect, in part, the current national interest in high-performance computing and networking.

The OFA did not participate in any Toolkit policy options. In post-Toolkit sessions this team contributed $15M to the Universities Team's "global village" educational program (N14), and $5M to a federal labs marketing program (S5) it originated. The support for education is considered part of the overall strategy set forth by the team (*partes pro toto*). However, the marketing effort does not have a clear link to

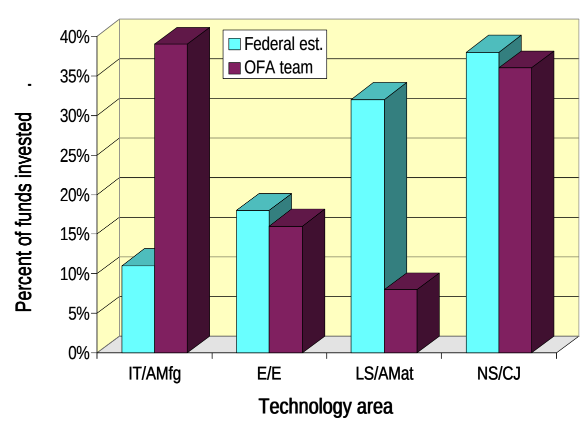


Figure D-7. OFA team technology R&D investments vs. estimated OFA real expeditures.

team plans (*carpe diem*), and it may be that the marketing effort was based on a frustration with industry being apathetic toward the federal labs in general. These investments had no effect on the overall planning score given to the team, and amounted to only 4% of the total team spending. The OFA Team was also credited with originating the idea for supporting critical industries that later became a law (L4).

Universities (U)

The Universities team was in a position second to only the IT/AMfg and Foreign teams in terms of financial capability to influence the game ($796M invested in R&D; comparable to E/E and LS/AMat teams' expenditures of $806M and $840M respectively). The team began by developing a lengthy list of "goals, objectives, strategies, observations, and problems" that did little to focus investment efforts. The only specific technology mentioned was to develop a national education delivery system including the conduct of related pilot projects. The U team did support efforts in this area ($100M to N4, and $5M to N16), but it did not originate the agreements. At best these investments might be considered a *partes pro toto* strategy (13%).

One major interest of the Universities team players was to attract "big science" projects, specifically from DOE. A related thread was the U team's desire to increase the market share of research they performed. However, little had happened in this regard by the end of session four. At this point the Universities team had come up with their own, ultimately successful (late session five) big project – a "war" on genetically predisposed disease (N26). In this effort they ended up sinking 42% ($334M) of their resources, and attracted an additional $343M (a one-for-one leverage).

The remaining $348M (44%) of the Universities' funds were expended on a variety of agreements. A total of $136M was spent on six information technology (T1, T5, N2, N15, N24) and advanced manufacturing (N29) efforts in addition to the $105M discussed above. Five agreements in various energy (N27, N33) and environment (T17, T18, N22) categories were supported with $75M. Finally $146M was spent on four agreements in the life sciences (T20) and advanced materials (N5, N17, N23) area. The fact that the U team did not support any initiatives within the national security or criminal justice fields, and invested only a small amount in energy in spite of a desire to attract DOE specifically, and a larger market share in general, shows that they did not really pursue their stated objectives. All of these investments would be categorized as being *carpe diem* in nature. Budget information for university R&D work by technology area was not readily available for comparing against the Universities team's investments. However, for the purposes of this report it was assumed that the R&D budget was proportional to the number of graduate students in any one field. The breakout of the Universities Team's investments by technology area, along with the estimated real distribution is provided in Figure D-8.

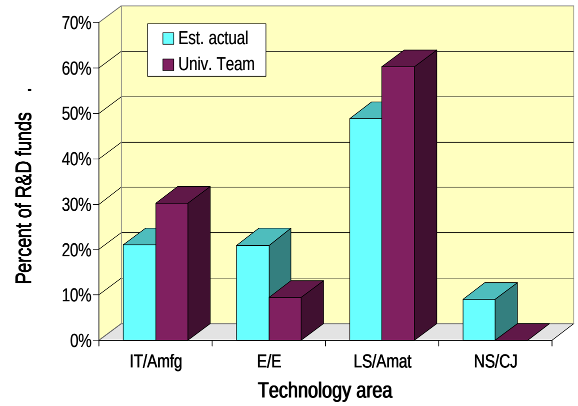


Figure D-8. University R&D expenditures by technology area.

The Universities team invested 7% ($60M) of their total expenditures toward non-R&D ("policy") agreements. Over one-half of this ($35M) was spent during the Toolkit session on option P46 that gave a 25% tax credit to industries on R&D efforts with traceable partnerships with universities or federal labs. Post-Toolkit policy funds were primarily spent on the team's "global village" educational project (N14) that was geared to provide students with global leadership, teaming and communication skills ($20M). An additional $5M was successfully invested in the NS Labs proposal (N25) to establish "Fraunhofer-like" institutes in the US using National Labs and universities that focused on specific technologies and markets. The Universities Team also originated a Toolkit policy option (P47; modification of P39) that would have authorized DOE to work together with foreign countries in conducting research on global environmental problems; neither the U Team nor any other team chose to fund this agreement. All of these policy investments were consistent with the stated goals, objectives, or strategies of the Universities Team, and are considered to represent *partes pro toto* behavior.

DOE National Security Laboratories (NS Labs; aka. Weapons Labs)

The NS Labs team developed an extensive set of goals and strategies that essentially defined a business model and did not list any specific R&D areas to pursue. The closest it came to this was to state that it would maintain a national security focus, albeit with a “broad definition;” no clarification or restriction to this was found in the team reports. It was explicitly stated in its goals that the team wanted to broaden the range of contributions it provided in science and technology. However, during each session, additional planning was conducted to help focus actual funding efforts.

One major thread found throughout the game play was a stated desire on the part of the NS Labs to evolve partnerships. And even though the stated position of this team was not to seek foreign partnerships because “they are not a benefit to the national security or US taxpayer ...” they were, in fact, solicited on a number of occasions. By most measures, this team was very successful in the partnering category. First, the NS Labs team raised the most outside capital, $812M, in support of agreements it originated, even though it only authored five. Second, this large amount of capital, coupled with its own investment of $82M (36% of NS Labs team funds spent on technology), gave it the highest leverage on its R&D dollars (9.9:1). Third, although the team was only ranked third in the number of agreements it contributed to (22; E/E did 26; IT/AMfg did 24; 18 average), the team was cash poor with only the DOE team spending less on technology; thus the NS Labs team spread or leveraged its money further ($10.5M per agreement on average) as opposed to investing in fewer agreements.

On actual investment strategies, review of game and team notes reflect that the NS Labs' lead role in the National Computing and Networking Initiative (N2; $35M) and the virtual reality trainer (N16; $10M) was based on a *crescit eundo* strategy that grew out of the ASCI (T3; $30M) and virtual workplace (T5; $10M) Toolkit options. The other serial thinking displayed by the team was their lead effort to follow-up the internal security Toolkit (T33) with an enhanced program (N12; $30M). The labs also led efforts to extend nuclear power plant life (T35; $3M) and to develop an advanced micro-electromechanical manufacturing capability (N29; $4M). Follow-on work was planned for the life extension work over several sessions, but sufficient interest could not be raised; however, this does demonstrate *crescit eundo* thinking. No links could be found in the documentation for N29, and it must be assumed that it was simply a good idea at the time (*carpe diem*).

In addition to these five agreements the NS Labs originated, and the two related Toolkit options discussed, this team participated in 15 other technology agreements. These can be summarized as follows: an additional $55M in networking and computing (N15); $10M in transportation (N27, N33); an additional $5M in nuclear power (N3); $10M in energy sources (N7, N8); $26M in various environmental programs (T17, T18, N11, N36); $10M in health (N26); $11M in advanced materials; and an additional $21M in national security (N13, S1). All of these investments in R&D (49%) can be considered to have been targets of opportunity for partnering, and thus the result of simple *carpe diem* strategy. This also leaves the impression that the team's desire to partner (good) and its limited resources tended to drive it into the mode of doing AFAB (anything for a buck) work. On the other hand, this reflects the stated desire on the part of the NS Labs team to provide contributions across a broad range of science and technology areas, in contrast to a narrow mission focus.

Although it did not have a role during game the actual game play, it should be mentioned that the NS Labs Team drafted a sixth R&D agreement (N40) near the end of the last session that had commitments from three other teams (E/E, NS/CJ, DOE) to develop the necessary electronics for an enhanced surveillance program of complex systems (e.g., maintenance, operational, or reliability status thereof).

In order to assess NS Labs Team investment interests in the game against reality, five year funding totals for Major Initiatives from the *Sandia National Laboratories Institutional Plan FY 1996-2001* were assumed to be representative of funding trends across the entire weapons lab complex. This assumption allowed differentiation between the major sub-technology areas in the game (e.g., IT vs. AMfg) that revealed interests that might otherwise have been obscured. A comparison of the technology areas invested in during the game to the published initiatives is provided in Figure D-9.

The NS Labs Team funded four policy agreements (more than any other team) with $37M (14% of total spending). Only one of these was a Toolkit option, P48, which was an unsuccessful agreement that the NS Labs team originated intended to provide a 100% tax credit for R&D sponsored by industry at universities or national labs ($4M). In another agreement originated by this team (N25), $20M was invested in a successful bid to establish "Fraunhofer-like" institutes in the US using National Labs and universities that focused on specific technologies and markets. In a third policy agreement drafted by the NS Labs, the team spent $8M in an unsuccessful bid to establish a nation-wide "marketing" tool for the labs – an Industry Technical Information Network (N35). In another marketing-related but OFA led effort (S5), the NS Labs team invested the remaining $5M. These four agreements funded by the NS Labs Team were not the only policy efforts they were involved in: They also drafted a successful, no-cost agreement (S3) wherein the DOE agreed to eliminate overhead charges on partnering agreements and to allow incremental cost recovery. All of these efforts are considered to be part of the labs effort to evolve or provide incentives for partnering under the goals established during the planning session (*partes pro toto*).

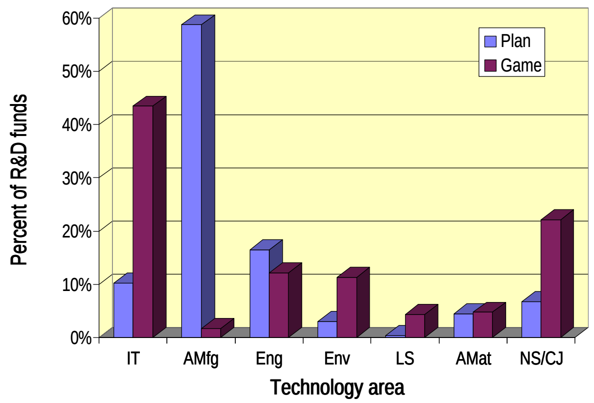


Figure D-9. NS Labs' game investments vs. estimated actual disbursements.

DOE Civilian Science and Technology Laboratories (S&T Labs)

During the planning session the S&T labs team developed a set of objectives, strategies, and tactics that were used, at least in part, to direct team play. Post-Toolkit the team also developed a set of investment initiatives. The technology R&D investment portions of these plans can be summarized as follows below. Business plans and policies, management actions, construction plans, and the like are excluded from consideration here.

A. Objectives
   1. fission, fusion, fossil, conservation, closed nuclear cycle, reprocessing/breeder
   2. higher temperature materials to support higher efficiency energy use
   3. zero manufacturing emissions, zero discharge emissions
   4. clean water
   5. "NOT suck, muck, and truck"
   6. reduce carbon fuel emissions
B. Strategy: "identify targets of opportunity [other teams ...]"
C. Tactics – invest in:
   1. fission
   2. fusion
   3. renewables
   4. clean fossil
   5. clean water
D. Initiatives – "start major initiatives on:"
   1. health
   2. computers
   3. energy
   4. environment
   5. water

Although some common threads can be found running through these plans, in general a vertical consistency among them does not exist, making evaluation difficult. The approach taken below was to simply evaluate these plans separately rather than as a whole.

Beginning with the technology objectives, fission was funded by the S&T Labs at a level of $5M (N3). (Efforts to extend existing nuclear plant life, T35, were not supported.) Agreement N3 was the only work within objective A1 supported by this team. However, if the term "conservation" is not taken in the implied context of power, but is applied to any energy conservation related projects, additional investments can be considered as partial fulfillment of this objective. These include: materials development for a hybrid vehicle ($25M; N5); room-temperature superconducting power conductors ($5M; N23); transportation modeling and simulation ($5M; N27); and an intelligent transportation infrastructure ($15M; N33). Thus it can be considered that the S&T Labs team devoted 2% ($5M) of their resources toward power cycles and 19% ($50M) in energy conservation programs, all geared toward their first objective. High-temperature materials (N10), objective A2, received $10M from the S&T team. Objective A3 was not supported. Objective A4 had several related game agreements that the S&T team could have supported, but it chose to only apply $10M to one agreement (N22). Three environmental remediation agreements received $40M in funds from the S&T Labs team (N6, N11, N36) in support of objective A5; agreement N36 was originated by the S&T Labs team. Objective A6 was not supported. Thus, in overall terms, 43% ($115M) of the S&T Labs' funds earmarked for technology were spent in fulfillment of its stated objectives.

The tactics given by the S&T Labs were primarily a subset of the objectives, except that "renewables" was added. Tactics C1 (fission; $5M; N3) and C5 (clean water; $10M; N22) are discussed under the objectives above. Tactic C3, renewables, was supported by one of the team's own agreements that successfully developed biomass technology ("NOVO Power" [sic]; $8M; N31). The team did not support the related, alternative vehicle fuel Toolkit (T12). In all, only 9% ($23M) of the team's technology money went toward pursuit of their tactics. This reduced performance over the objectives is not understood except in that the tactics seemed to be largely ignored.

After the Toolkit session, the S&T Labs decided that it wanted to start major initiatives in five areas. This behavior is not unlike that of the Universities team that wanted a "big science" project. Since the term "major initiative" was not defined by the S&T Labs, evaluation could only be based in terms of the overall game play. Out of the entire set of 49 technology agreements (includes Toolkit investments), the top ten in terms of investment size were all $260M or larger (and represented 50% of the total R&D investments). The largest agreement originated by the S&T team was the brown field remediation project (N36) that had a total investment of $215M ($20M team; 7.4% own funds; 7 total participants). The team also wrote three smaller agreements: spallation neutron source (N17; $50M total; $25M team; 9.3% own funds; 6 total participants); biotechnology and agriculture project (N32; $110M total; $10M team; 3.7% own funds; 3 total participants); and the biomass technology project mentioned above (N31; $158M total; $8M team; 3% own funds; 5 total participants). Side stepping the "major" question (the team was cash poor, and without sufficient support by others a "major" agreement could never be developed), it can be asked if the team began any initiatives at all in the five stated areas. From this point of view, initiative D3, energy, with the biomass project, and initiative D4, environment, with the remediation project, had some attention ($28M or 10% of the team's resources). The other two initiatives supported advanced materials and food production (life sciences), which had not been targeted by any of the team's plans. If the team's agreements are evaluated on their own merit, they did quite well. With the $63M invested in these four agreements by the S&T labs team, they raised another $470M, which equates to a 7.5:1 leverage ratio. Only the NS Labs team had a better leverage on their funds than this in agreements they originated.

In addition to the thirteen agreements the S&T Labs participated in that are discussed above, 41% ($111M) of their R&D resources were spent in eight other agreements. These can be summarized as follows: $45M in networking and computing (N2, T5); an additional $5M in power technologies (N28); an additional $9M in energy sources (N7, N8); an additional $20M in environmental related activities (T18); and $32M in health technologies (T20, N26). Because of the breadth of the S&T Labs technology base, certainly all of these activities can be considered as relevant.

The last stated S&T Labs initiative to be discussed, *strategy*, indicates that the team had no original intent to take anything other than a *carpe diem* approach. Certainly they fulfilled this goal and more. The explicit plans and follow up to invest in fission (N3; $5M), clean water (N22; $10M), remediation technologies (N6, N11, N36; $40M), and renewables (N31; $8M), probably represents a tendency toward a *partes pro toto* strategy with at least some of the teams resources (23%).

The S&T team performed with a technological focus very much in keeping with the existing paradigm. This team devoted 17% of its technology resources into the IT&AM area, 43% into the E/E area, and 40% into the LS&AM area. Of specific note to this game is the fact that the team was very vocal in wanting work within NS&CJ, yet they did not partner in nor originate any agreements in this area.

To compare the S&T Labs investments against their "constituency," the FY1993 budgets for these labs were broken down by technology area with the assumptions that: (1), work for others and work for other DOE labs represents an even spread or cross cut across all program areas; (2), "other DOE programs" are life sciences or advanced materials; and (3), 10% of E/E and defense programs work goes for IT, and another 10% goes for life sciences and advanced materials. Team investments versus the resulting FY1993 budget breakout are shown in Figure D-10.

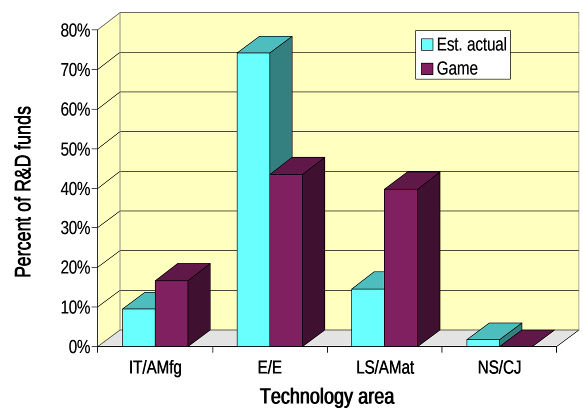


Figure D-10. Civilian S&T Labs technology investments.

The S&T Labs made $20M in investments (7% of their total) in three "policy" agreements that were originated by other teams. One-half of this went toward R&D tax incentives (P46), while the other half went toward "marketing" efforts ($5M each to N35 and S5). The S&T Labs did originate one Toolkit policy option (P43) that remained unfunded; if it had passed, this agreement would have maintained a vigorous funding level of the S&T lab system ($1.5B/yr). All of these policy investments were consistent with the stated team strategies or tactics (*partes pro toto*).

Foreign Countries

Although the Foreign team was able to quickly establish their role (constituencies) and develop an initial set of priorities, team records show that the technology focus was poor, and shifted throughout the game. Based in some measure on the team records, the following prioritized, composite foreign technology interests list was compiled:

1. food
2. clean water
3. energy/sustainable energy
4. infrastructure
5. education
6. health
7. secure telecommunications

Other strategies or objectives given had more to do with policy (e.g., technology access, market access, etc.). However, there is one policy statement that must be considered in evaluating the foreign R&D investments.

[The foreign team should]... invest in those ... technology options which are critical in some parts of the world, and without which US R&D ... alone would have little impact.

Thus a proper evaluation of actual investments by the Foreign Countries team will consider not only the technology areas of interest, but also the importance of the contribution. For the purposes herein, a contribution will be considered important (having impact) if it dominated the respective agreement (50% or greater of the total or otherwise clearly controlling the activity), or was significant in size and necessary to achieve a reasonable success probability (50%). With this definition, it was found that the foreign team made critical investments with 70% ($885M) of their R&D resources that were all within one of the technology interest areas. The largest investments ($590M total) were made in the top priority area of food production as follows: foreign team biotechnology effort ($400M; N37); recombinant DNA technologies ($100M; T23); and the S&T biotechnology and agricultural project ($90M; N32). Another $180M was spent on the Global Clean Water Initiative (T17), which met the needs of the second priority technology item. No critical investments were made in energy or infrastructure. One of the game's education-related agreements, N4, was originated by the foreign team, and although they only controlled 45% of the total funds with their $90M contribution, the investment was crucial in exceeding the 50% probability-of-success point. Finally, in a third foreign-initiated effort (N30), this team used $25M in developing a quick HIV test. No critical investments were made in the seventh item of the priority list, secure telecommunications. All of the critical investments can likely be considered as having followed a *partes pro toto* strategy.

Although not of the critical category, some of the other agreements funded by the foreign team are directly related to those placed there, and are thus interpreted as being part of the same strategy. These additional investments are: foreign initiated desalination program ($20M; N22); and participation in all other post-Toolkit health programs ($96M; N1, N26, N34).

With less evident planning, the foreign team sunk the remaining $270M (21%) of R&D capital into a variety of agreements in what must be considered *carpe diem* strategy. Given a broad interpretation of the technology interests listed above, these investments can be summarized as follows:

1. In the interests of developing **energy**, $115M was invested in advanced controls (N9), sustainable sources (N31), higher-efficiency thermal cycles (N10), higher-efficiency and capacity power distribution (N23, N28), and advanced batteries (N8).
2. In the interests of developing advances in **infrastructure** capability and capacity, $155M was invested in communications (T5), manufacturing (N29), and transportation (N27, N33).

From an overall game R&D investment perspective, the foreign team priorities are clearly evident. A total of $766M was devoted to life sciences and advanced materials, $355M was invested in energy, and $150M was spent in information technologies and advanced manufacturing. Noticeably absent was any significant interest in the environment or defense. When these investments are compared with the distribution of actual foreign money in US R&D as shown in Figure D-11 (see Foreign Team Briefing in Appendix I for details), the large interest in energy during the game is seen to represent "out-of-the-box" behavior. Whether this represents a significant, increasing and real concern on the part of foreign countries, or whether it simply represents the particular interests of the players is not known.

Non-R&D investments by the foreign team can be divided into two categories: "policy" and capital. The foreign team did not make any policy investments during the Toolkit session. During the post-Toolkit play, the team did support the Universities' "global village" educational project (N14) with $20M, which is consistent with one of the team's basic interests (*partes pro toto*). The team also supported the NS Labs proposal (N25) to establish "Fraunhofer-like" institutes in the US using the national labs and universities with $5M, although it is not clear how they were to benefit (*carpe diem*). Capital investments were made by the team in two agreements they originated (N38 and N39) for building an automotive plant and a semiconductor/telecommunications plant to support sales in China. These two agreements did not have any partners, and were funded by World Bank loans ($100M each). Both of these capital investment programs were in keeping with team plans (*partes pro toto*).

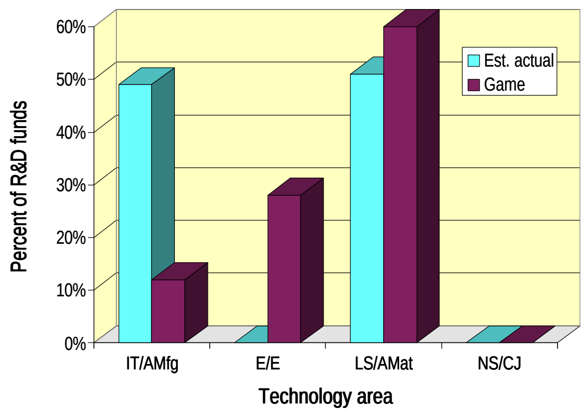


Figure D-11. Foreign team expenditures by technology area vs. reality.

Appendix E: Agreements and Contracts

Option Number		Time	Quality, Defense	50% Prob. Cost	Total Invested	Total Probability	PASS or FAIL	US Congress	Ind 1 (IT/AMfg)	Ind 2 (E/E)	Ind 3 (LS/AMat)	Ind 4 (NS/CJ)	Dept. of Energy	Other Agencies	Universities	DOE NS Labs	DOE S&T Labs	Foreign
	SESSION 3: INVESTMENTS																	
N1	Demonstration of system and standards for telemedicine, diagnosis, and health management.	15:11	Q	50	100	0.71	PASS		40		40							20
N2	National computing and networking initiative to result in a secure, high-capacity, high-bandwidth capability.	15:16	D	200	260	0.52	PASS	10	50			50	5	25	50	35	35	
N3	Non-LWR nuclear power plant study to determine efficiency, safety, and economics of non-LWRs.	15:31		10	20	0.84	PASS			10						5	5	
N4	Technology for education initiative to develop and deploy technology focused on public and worker education.	15:35	Q	150	200	0.65	PASS							10	100			90
N5	Materials for hybrid vehicle: catalytic cracking hi-yield processor, light-weight recyclable composites, power sources.	15:41		250	290	0.64	PASS		50	5	100			5	100	5	25	
	Session 3 Totals			**660**	**870**			**10**	**140**	**15**	**140**	**50**	**5**	**40**	**250**	**45**	**65**	**110**
	SESSION 4: INVESTMENTS																	
N6	Environmental remedial technologies: in-situ HC, heavy metals, and radioactive materials remediation.	15:49	Q	20	30	0.63	FAIL			20							10	
N7	Deep-water oil and gas production technology program to increase operating water depth of off-shore oil platforms in the Gulf of Mexico.	16:00		15	28	0.70	PASS			20						4	4	
N8	Advanced battery program to develop light-weight, long-life batteries.	16:51	D	200	322	0.81	FAIL		105	105	50	31		10		6	5	10
N9	Smart buildings that provide energy management and security/safety over-sight through hard/software advances.	16:51		90	180	0.81	PASS		110	50				10				10
N10	High temperature materials for improved efficiency, reliability, performance in engines, turbines, etc.	16:55		100	150	0.67	FAIL			55	30			10			10	45
N11	N6 - second try (remediation techs)	17:02		20	50	0.87	PASS			20			5			15	10	
N12	Internal security program to enhance safety of citizens from internal threats.	17:04	Q,D	180	318	0.84	PASS	20	25			153	10	80		30		
N13	Deep earth penetrator: design of highly accurate, low yield, deep earth penetration nuclear weapon.	17:08		50	50	0.45	PASS							40		10		
N14	Global village program to utilize technologies developed under T5 (virtual work environments) and N4.	17:15	Q	40	75	0.92	PASS		20					15	20			20
N15	Advanced information surety systems to build upon N2.	17:22	Q,D	150	225	0.76	PASS		140		50				20	15		

N16	Virtual reality trainer; total immersion interactive training tool.	17:28	Q	50	68	0.57	PASS		25					28	5	10		
N17	Spallation neutron source to support advancing state-of-the-art knowledge for high-temperature materials.	17:28		50	50	0.44	PASS	5	5	5	5				5		25	
N18	High-speed mass transit program: controls, materials, and design for systems for the high density corridors in US East.	17:31	Q	100	200	0.95	PASS		120	10	60			10				
N19	N8-second try (advanced batteries)	17:44		1	9	1.09	PASS			9								
N20	N10-second try (high temp materials)	17:44		1	9	0.86	PASS			9								
	Session 4 Totals			**1067**	**1764**			**25**	**550**	**303**	**195**	**184**	**15**	**203**	**50**	**90**	**64**	**85**
	SESSION 5: INVESTMENTS																	
N21	Low cost tracking: suite of sensors for safety/asset tracking.	11:04	Q,D	50	100	0.82	PASS		20			80						
N22	Implementation of the technologies developed under the Clean Water Initiative in desalination plants.	11:24	Q,D	50	100	0.86	PASS		60						10		10	20
N23	Room-temperature superconductors (300K) with long-term durability.	11:27	D	200	292	0.70	PASS		70	30	130	10	5	10	16	6	5	10
N24	Low-cost Internet access computer at $100-per-unit.	11:27	Q,D	20	40	0.72	PASS		20	5	5	5			5			
N25	Establish Fraunhofer-like institutes: potential focuses were next-generation photolithography andgenome tech.	11:37		10	30	1.05	PASS								5	20		5
N26	War on genetically predisposed diseases to develop causal relationship between genetics and diabetes and Alzheimer's. Foundation for other diseases also.	11:46	Q	500	677	0.27	PASS	31	110	35	20	50		15	334	10	22	50
N27	Surface transportation modeling and simulation program to modify existing infrastructure for more efficient usage.	11:53	Q	100	211	0.93	PASS	10	100	50	10	20		5	5	1	5	5
N28	Improved electrical grid capacity; development of new power conductors and other technologies to increase carrying capacity of current system.	11:57	Q	60	121	0.95	PASS		50	22	10			14			5	20
N29	Advanced micro-electromechanical manufacturing initiative to develop next generation of submicron tech.	12:01	D	100	215	0.97	PASS		120		40			20	1	4		30
N30	HIV detector that can provide test results within a few minutes. Rugged and portable for worldwide use.	12:01	Q	20	26	0.66	PASS			1								25
N31	Biomass technology deployment: related assets from ORNL and NREL privatized as a seed to develop new technologies.	12:04	Q	80	158	0.96	PASS	10	100	20							8	20
N32	Biotech and agriculture project: development of sensor and instrument suites for measuring soil and chemical properties.	12:05	Q	50	110	0.88	PASS		10								10	90
N33	Intelligent transport infrastructure prototype utilizing innovative technology.	12:10	Q	200	339	0.83	PASS	10	100	20		45		10	30	9	15	100
N34	Cure for an emerging viral threat in third-world countries.	12:10	Q	30	87	0.82	PASS	5	45		10			1				26
N35	Industry technical information network - single point of marketing for the federal lab system.	12:11		10	18	0.87	FAIL		5							8	5	
N36	Brown-field site remediation in inner-city neighborhoods using N6/N11 technologies developed earlier.	12:13	Q	75	215	0.89	PASS	5	50	55	50			30		5	20	

N37	Biotechnology development with specific application to the needs of Canada and Europe (e.g. food production).	12:16	Q	200	400	0.81	PASS											400
N38	Europe-Japan-Korea consortium to produce automotive vehicles for China	12:18		100	100	0.55	PASS											100
N39	Canada-Japan-china advanced semi-elcon	12:20	Q	100	100	0.48	PASS											100
N40	Enhanced system reliability for complex weapons systems. (Not funded)																	
	Session 5 Totals			**1955**	**3339**			**71**	**860**	**238**	**275**	**210**	**5**	**105**	**406**	**63**	**105**	**1001**
	Subtotals =			**3682**	**5973**			**106**	**1550**	**556**	**610**	**444**	**25**	**348**	**706**	**198**	**234**	**1196**
	OTHER INITIATIVES																	
S1	Study done for OFA by the NS Labs to identify best industrial technologies with potential to serve OFA needs.													9		11		
S2	NS/CJ industry - NS Labs allocation agreement for Toolkit investments.																	
S3	DOE agreed to eliminate overhead charges associated with partnerships.																	
S4	DOE provided S&T Labs additional funding (9M) to identify R&D areas of importance to E/E industries.																	
S5	Marketing system to promote capabilities of federal labs to customers.													5		5	5	
	LEGAL INITIATIVES																	
L1a	Requirement that federal labs spend at least 25% of funds with the private sector.																	
L1b	Repeal of the existing R&D tax credit laws in favor of Nunn-Domenici.																	
L2	Nunn-Domenici tax reform passed where income tax replaced with a consumption-based tax.																	
L3	DOE required to submit a plan to eliminate redundancy among labs.																	
L4	Congress passes Critical Industries Preservation Act to maintain critical capabilities on US soil.																	
L5	Department of Commerce replaced by Department of Economic Security to coordinate economic development, etc.																	
L6	Anti-terrorism act enables joint program to combatting terrorism.																	
L7	Amendment of anti-trust laws to permit coordination, joint research, etc.																	
L8	Opening of the Arctic National Wildlife Refuge oil fields for production.																	
L9	Entitlement Control Act phases down growth rate of Medicare.																	
L10a	R&D tax credit provisions of the N-D tax reform further enhanced for joint industry-lab and/or university efforts.																	
10b	Temporary Science Department created with a charter to reduce redundancy.																	

10c	Funding increased to the SBIR program.																	
L11	Trade initiatives requiring precondition on all international agreements.																	
L12	Congress authorizes formation of a Lab closing commission (like BRAC).																	
L13	Excess facilities sales enablement Act.																	
L14	Streamlining of FDA approval process.																	

Appendix F: News Releases and Surveys

Questionnaire for Other Teams from the
DOE National Security Labs

Other Team Name: _Universities
What can the DOE National Security Labs do for you?
Assist teams who jointly address common problems (e.g. Hazardous Waste clean-up; computation tools; joint appointments; and use their multidisciplinary approaches to help frame scientific problems.
What are your major R&D problems?
Money. Access to "big-science" tools; an infrastructure for support of fundamental science; education delivery systems for the future.
What would be the ideal relationship between you and the National Security Labs?
Money. An easy environment for exchange of researchers (faculty and students and funds).
What would you like to see changed at the DOE National Security Labs?
Perceived "block" environment.
What would you like more of?
Additional collaboration.
What would you like less of?
Competition on basic fundamental research. Agency bureaucracy, micromanagement of DOE. Research, teaching, add value to National Security Labs.

Other Team Name: __***DOE Civilian S&T Labs***
What can the DOE National Security Labs do for you?
(no answer)
What are your major R&D problems?
B. S. infrastructure (long range global energy strategy; robust energy program, governmental R&D.
What would be the ideal relationship between you and the National Security Labs?
(no answer)
What would you like to see changed at the DOE National Security Labs?
(no answer)
What would you like more of?
(no answer)
What would you like less of?
(no answer)
Note at the bottom of the page: They will let us into E&E. Will we be willing to let them into National Security?

Other Team Name: __***DOE***
What can the DOE National Security Labs do for you?
Focus on corporate mission, accomplishments; provide industrial resources through partnerships in support of mission.
What are your major R&D problems?
Sustainable energy technologies; integration of Dept.'s science and technology; environmental cleanup research to lead to reduced costs, simulation on a large scale.
What would be the ideal relationship between you and the National Security Labs?
Partnership with all partners (? Can't read copy).
What would you like to see changed at the DOE National Security Labs?
Demonstrated cost efficiency
What would you like more of?
Corporate (can't read copy)
What would you like less of?
Arrogance and isolation.

Other Team Name: ***U. S. Industry #3, Life Sciences and Advanced Materials***
What can the DOE National Security Labs do for you?
Provide scientists and funding for the development of the materials that we have identified; make high end computer technology available over internet.
What are your major R&D problems?
Funding and technical resources (scientific help) that will allow the development of materials that can be delivered to market in two years..
What would be the ideal relationship between you and the National Security Labs?
The labs would provide us with any materials that they develop that is applicable to our industry. They would also help fund all R&D activities via defense contracts. Part of NL mission has to mention industry.
What would you like to see changed at the DOE National Security Labs?
The labs should open the doors to a greater percentage of their funds alleviated to their industry.
What would you like more of?
25% of the resources applied to advanced materials.
What would you like less of?
A smaller portion of industry investment applied to high risk development projects.

Other Team Name: __***Foreign Countries***
What can the DOE National Security Labs do for you?
Securing access to communication/BDI/cheap communication device with long range bandwidth.
What are your major R&D problems?
Portable energy/electricity sources; fresh water and distribution.
What would be the ideal relationship between you and the National Security Labs?
No direct relationship but through the marketplace.

What would you like to see changed at the DOE National Security Labs?
(no answer)
What would you like more of?
Securing personal privacy as part of Human Rights endeavors; fighting international crime/terrorism.
What would you like less of?
(no answer)

Other Team Name: __***Other Federal Labs***_
What can the DOE National Security Labs do for you?
Worldwide R&D lead in specific areas: materials, high-per (can't read copy),microelectronics, energy technologies, optical electronics; safe, reliable nuke deterrent; state-of-the-art intelligence.
What are your major R&D problems?
No answer
What would be the ideal relationship between you and the National Security Labs?
Serve as partial replacement for in house R&D.
What would you like to see changed at the DOE National Security Labs?
Realignment of structure to accomplish #2 (industry workforce and overall lab structures.
What would you like more of?
(no answer)
What would you like less of?
(no answer)

Other Team Name: _***Industry - 4 (CJ/NS)***_
What can the DOE National Security Labs do for you?
Support in implementing P-15, and our tool kit options on R&D flat tax, and matching R&D funding for partnerships; conduct R&D in areas mentioned in answer to No. 1.
What are your major R&D problems?
Funding for research in advanced technologies in area of detection; (? - can't read) on proximity material and bio-sensors; expert systems; light-weight batteries.
What would be the ideal relationship between you and the National Security Labs?
Use 25% of budget to partner with industry in one for one match.
What would you like to see changed at the DOE National Security labs?
Change in intellectual property rights to industry..
What would you like more of?
(no answer)
What would you like less of?
(no answer)

THE FOLLOWING THREE PAGES CONTAIN NEWSLETTERS THAT WERE HANDED OUT TO EACH TEAM AT THE APPROPRIATE TIME DURING THE GAME.

THE FOURTH PAGE CONTAINS A NEWSLETTER THAT WAS NOT HANDED OUT SINCE THE ACTIONS TAKEN DURING THE GAME PRECLUDED THE SCHEDULED EVENTS NAMED IN THE NEWSLETTER.

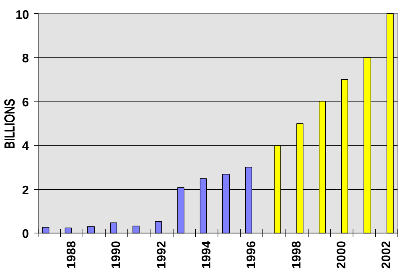
December 31, 1996 Volume 1

The Prosperity Times

ECONOMICS

U.S. Investments in China

U.S. dollars flowing into "foreign-invested enterprises" in China have reached an all time annual high of $4B. Under current trends, cumulative U.S. investments will reach the $35B mark by the turn of the century.



Some investment councilors have been expressing caution concerning investments in China because: (1) no bilateral investment treaty has been negotiated; (2) few investments are protected by risk insurance; (3) the Chinese emphasize resolving disputes by informal conciliation, and the Chinese have a bad record of ever following through on arbitration commitments; (4) repatriation of profits can be difficult; and (5), China has failed to satisfactorily enforce the Protection of Intellectual Property Rights agreements it entered into in 1992.

U.S. Pressures China

The U.S. vows to keep China out of the WTO unless suitable progress is made in resolving issues associated with the draft investment treaty, including strong enforcement and arbitration support of existing agreements. Confidential sources report that the U.S. is seeking ways to use the strength and influence of foreign-enterprise companies in China with local officials in solving problems at a grass-roots level. To date, those companies have been quiet about the issues.

Chinese State Industries in Trouble

Major state industries (iron and steel, coal, machine building, armaments, and textiles) have now spent almost two decades in "reform" with little effect. Productivity has continued to fall sharply, markets have receded, and costs of production and debt levels have been steadily increasing. By way of contrast, industrial growth in the private sectors has averaged close to 20% for several years. The industrial output of Sino-foreign ventures and solely foreign-owned enterprises rose 56%. Since the central government depends heavily upon income from state-owned enterprises, projected budgets will have to rely on heavier tax burdens on other sectors. Chinese leaders declared that next year would see the institution of "quality, variety, and efficiency." Factory managers were called on to cut losses and boost productivity.

Gasoline Prices rise again

The average price of gasoline reached $3.25 per gallon this month. A spokesman for a major oil supplier, preferring to remain anonymous, said “It’s simply a case of supply and demand. Following an abnormally cold winter in 1995, an exceedingly cold winter world-wide has shifted refineries heavily into the production of heating oil. However, the cost of oxygen additives has also contributed significantly to the price increase. The days of cheap gasoline may be over for the U.S.” A second major petroleum firm recently announced that it would renew its research efforts into conversion of oil shale and coal liquefaction. A member of the Senate Energy and Natural Resources Committee has asked DOE to revitalize its hydrogen fuel program. Environmental scientists have been quick to point out that several years of bad winters does not negate the overwhelming long-term trend toward global warming.

POLITICS

Chinese protest U.S. aggression

The Chinese government has staged mass anti-U.S. demonstrations that reportedly involve millions of party members. The demonstrations follow widespread viewing of a documentary army film entitled "Confrontation" that is meant to stir up support for the "war" against U.S. aggression and U.S. aid to Korea.

December 31, 1997 Volume 2

The Prosperity Times

NUCLEAR PROLIFERATION

N. Korea halts IAEA inspections

Democratic People's Republic of Korea - officials announced a halt to inspection of its nuclear facilities. Citing IAEA inspectors' disregard for the sovereignty of DPRK, officials declared the 1992 NPT safeguards agreement was in abeyance pending review. The U.S. threatened sanctions if DPRK continued to resist inspections. DPRK responded by accusing the U.S. of driving the situation to the brink of war, and warned that Seoul would be rendered "a sea of fire" if hostilities broke out. IAEA inspectors had been successful in gaining access to most of the DPRK nuclear facilities since the October 1994 U.S.-North Korea Geneva agreement.

POLITICS

China-Taiwan Talks Collapse

Discussions between officials of the governments of China and Taiwan came to a stalemate over reunification. Chinese Foreign Ministry spokesman Shen Guofang has stated that "peaceful reunification and 'one country, two systems' continues to be our basic policy towards Taiwan." However, in a press release by Chang King-yu of the Taiwanese' Mainland Affairs Council, it was claimed that China is mandating provisions that will cripple Taiwan by requiring conformance with existing PRC policies and law. It is expected that Taiwan will begin to aggressively seek independence. Shen meanwhile has restated the PRC's position that "in the circumstance of Taiwan's independence, China will certainly take all necessary measures to protect the motherland's sovereignty and territorial integrity." The stated U.S. policy, based on the Taiwan Relations Act of 1979, is "to consider any effort to determine the future of Taiwan by other than peaceful means, including boycotts or embargoes, a threat to the peace and security of the Western Pacific area and of grave concern."

COMPUTING

Disaster on the Net

A Trojan horse virus caused a large number of computers to crash worldwide in what must be the most insidious and widespread infection ever. Computer experts are blaming a particularly well-crafted piece of code embedded in the basic kernel of the UNIX operating system, which is one of the most widely used computer operating systems in the world. This particular virus has evidently been planted since the early '70s when the first 'C' version of UNIX was written, and has remained invisible to later developers as they have modified and expanded the code to meet current system needs. Widespread fallout from the virus occurred as transportation, communication, and banking systems were crippled.

ECONOMICS

China Announces New Tax Rates

In an effort to bolster its failing state industries, China has announced modernization plans that will be supported from taxes on foreign-invested companies. Government officials stated that foreign capitalists were profiting off of the hard work of the people, and it was only right that they should invest those profits back into programs that would help the people. Under the new law, all companies with foreign investment will have their gross income taxed at 40%, an increase of 7%.

North Korean Rocket Test

North Korea recently conducted a second successful test of its latest ballistic missile, called the Taepo Dong 2, that could have a range sufficient to reach Alaska. The missile may also be capable of reaching some US territories in the Pacific and the far western portion of the 2000 km-long Hawaiian Island chain. The DPRK also has demonstrated shorter range missile capabilities with its own version of a Scud B missile (range of 175 miles), a Scud C missile (range of 375 miles), and the No Dong 1 missile (range of 625+ miles).

December 31, 1999 **Volume 3**

The Prosperity Times

SCIENCE

Is There Waste in Your Backyard?

Medical-, power-, and weapon-related radioactive wastes continue to pile up, and their ultimate disposal represents a major national problem. In a related issue, cleanup of nuclear weapons development wastes at some 120 sites in 36 states and territories continues to lag far behind plans. Legal actions and posturing among the environmental community, congress, responsible federal agencies, companies, states, environmental laws, the administration, and other stakeholders continue to leave the U.S. without a coherent policy that might enable effective progress. Legislation passed in the '80s intended to resolve these issues has proven to be ineffective in actually providing a solution. The public, of course, continues to hold the bag in the form of increased costs for medical treatment, power, and taxes.

POLITICS

Taiwan Member of World Trade Organization

Taiwan has been granted membership in the World Trade Organization with the strong backing of its western trading partners. The PRC continues to be denied membership based on its long standing problems in protecting investments and property rights. Saturday, some 200,000 Taiwanese protested against China. Chanting "Taiwan independence" and "No reunification with China," the protesters marched through the streets of Taipei. The march was organized by Taiwan's Democratic Progressive Party which supports independence from China.

WTO HEADQUARTERS, GENEVA

Xiaoping Dies

Following Deng's death, a major shakeup in the central government of China has taken place. The expected successor, Jiang Zemin, has not been heard from since the announcement, and is reportedly in hiding. The Central Military Commission (CMC), composed primarily of 'hard liners' who favor such moves as the takeover of Taiwan, has announced the successor as Ye Ping, an unknown in the West.

ECONOMICS

Chinese Economy Falters

High-tax burdens on foreign-invested companies, excessive government corruption in granting licenses, bankrupt state industries, and a sharp drop in investments and tourism, all contributed to the declining Chinese economy. China's leaders have issued repeated reassurances that the new government is stable and that its foreign policy will continue to reasonable.

China and North Korea Sign Pact

In an apparent response to recent economic policies of international organizations such as the World Trade Organization, the World Bank, and the Ex-Im Bank, the People's Republic of China and the Democratic People's Republic of Korea signed a far reaching accord pledging development of an economic hegemony in the Far East. Although the full text has not been released, the agreement reportedly includes provisions for military cooperation.

China Seizes U.S. Assets

In the first case of expropriation since China opened to the outside in 1979, all US investments were nationalized under the "special" circumstances clause of the joint venture law. Government representatives cited: the deliberate policy of the US in undermining state industries to foster the collapse of the "socialist market" economic structure of the PRC; espionage and sabotage of recent PRC Army activities and installations by "CIA spies" using industrial ventures as a cover; attempts at economic coercion to give US investments even more control over China's economy; and US policies that attacked China's sovereignty. It is estimated that the amount of US investments in China affected by this announcement exceeds $53B. Although Chinese law calls for compensation of expropriated foreign investments, it does not define the terms of compensation.

December 31, 2001 Volume 4

The Prosperity Times

(Note: This issue not handed out)

DEFENSE

China, N. Korea join forces

China announced that it was initiating a major combined-arms exercise that was to include DPRK forces. The "games" are to take place in the Shenyang and Nanjing military regions, although forces from the Jinan region will also participate.

Operations in Nanjing are to include a division of airborne troops, a brigade of naval infantry, and selected regiments from three amphibious warfare army divisions.

Missile tests

After issuing advisory notices, China expanded its current exercises to include tests with tactical missiles, IRBMs and ICBMs. Two target zones correspond to ones used in 1996.

The third target area was located just outside of the U.S. 200-mile economic zone off Los Angeles. Both the Dong Feng (East Wind) 5 and the Dong Feng 31 were launched successfully. The Dong Feng 31 is a mobile ICBM that represents only one of the new generation of Chinese weapon systems. First tested in 1995,

it represents a significant advance over the Dong Feng 5, which is silo based. Both missiles have a range of 5,000 miles, allowing them to reach Europe and the U.S. west coast.

Invasion

Although perhaps not unexpected in some corners, the Chinese forces taking part in the most recent combined-arms exercise have seized the Kinmen, Machu, and Penghu islands belonging to Taiwan. Terrorist or guerrilla activities on Taiwan have also crippled that island's power and communications grid, and little news

has been forthcoming. In a surprise but apparently coordinated maneuver, North Korean forces have smashed across the demilitarized zone in a pincer movement and have Seoul under siege.

Standoff

In the first announcement since the invasion of Taiwan and South Korea, the PRC and DPRK issued a joint warning to the U.S., U.N., and other countries not to interfere in their internal affairs. The statement claimed: (1) the separation of sovereign territory from oversight by the duly constituted governments was driven by imperialistic goals of the US; (2) the present fighting was regrettable, but all peaceful attempts at reconciliation had failed; and (3) that all people within the affected lands will be treated with due respect, provided that they do not bear arms against the rightful government. In a separate statement the Chinese Army Chief-of-staff was quoted as saying "The situation will not get any tenser as long as America does not become involved." The U.S. administration has yet to announce any plans for dealing with the situation. Russian influence in the U.N. security council has prevented that body from taking any action.

Phone Systems Disrupted

The American Technocratic Association claimed responsibility for the recent communications blackout that affected most telephone systems. In a coordinated strike, 'crackers' penetrated software systems that control the Public Switched Network (PSN) used by the telephone companies nationwide, and the controllers for the IRIDIUM communication satellites. Although the PSN servers were back online within a day, the constellation of IRIDIUM satellites remain non-responsive to ground controllers. The loss of communication systems for most of a day reportedly cost billions of dollars to U.S. industry as it basically brought all commerce to a halt.

Appendix G: Toolkit

Option Number		50% Prob. Cost	Total Invested	Total Probability	PASS or FAIL	US Congress	Ind 1 (IT/AMfg)	Ind 2 (E/E)	Ind 3 (LS/AMat)	Ind 4 (NS/CJ)	Dept. of Energy	Other Agencies	Universities	DOE NS Labs	DOE S&T Labs	Foreign	Control
	Assets available $ >>		2850			550	300	300	300	300	100	150	150	50	50	300	300
	TECHNOLOGY OPTIONS																
Information Technology and Advanced Manufacturing																	
T1	The Accelerated Strategic Computing Initiative (ASCI) is continued, and a 15 teraflops machine is completed and available for use in the year 2000 (5 years).	200	10	0.14	N/A								10				
T2	If T1 succeeds, ASCI is continued, and a 100 teraflops machine is completed and available for use in the year 2003 (5 years).	200	0	0.15	N/A												
T3	Industry becomes a partner in the ASCI program by contributing funding and expertise (2 years).	50	50	0.48	FAIL						20			30			
T4	A major new program is launched to ensure the integrity and security of the national information infrastructure and telecommunications system to protect both government and business transactions (3 years).	150	70	0.32	N/A	70											
T5	Advances in bandwidth, software, and related technologies allow virtual work environments to become practical with applications to the workplace and education (4 years).	250	509	0.78	PASS		250	49			20	100	50	10	10	20	
T6	A joint laboratory-university program is created to develop and deploy new technologies to reduce costs and increase quality of education in US schools (K-12) and colleges (4 years).	200	0	0.14	N/A												
T7	Industry becomes a partner in the Advanced Design and Production Technologies (ADaPT) program by contributing funding and expertise (2 years).	50	0	0.17	N/A												
T8	The DOE, DOD, DOC, labs, industry, and universities establish a virtual enterprise to cooperate on technology projects similar to the Technologies Enabling Agile Manufacturing (TEAM) effort. Each investment here is for a specific agreed upon project (like agile manufacturing, etc.) (5 years).	100	0	0.14	N/A												
T9	The DOD funds a joint industry-government R&D effort on micro-electromechanical systems (3 years).	120	0	0.17	N/A												
T10	The US launches a national program to develop and deploy intelligent control and traffic management systems at local and regional levels.	60	0	0.18	N/A												
Energy and Environment																	
T11	DOE sponsors a program that increases the efficiency of the use of gasoline by 10% (5 years).	50	105	1.00	PASS	50		50			5						

T12	A joint industry-labs-university program is launched to develop alternative efficient and clean fuels for vehicles (5 years).	300	5	0.14	N/A						5						
T13	US participation in the International Thermonuclear Experimental Reactor (ITER) program is fully funded (10 years).	1000	0	0.15	N/A												
T14	DOE creates a national program to develop and deploy new environmental cleanup technologies at the national labs (5 years).	300	0	0.14	N/A												
T15	The US launches a jointly funded (industry-government) national program to encourage the replacement of current manufacturing processes with "sustainable" processes - i.e., industrial ecology (3 years).	150	0	0.14	N/A												
T16	The US launches the National Water Initiative to develop systems for cleaning and recycling water (10 years).	300	0	0.17	N/A												
T17	A Global Clean Water Initiative is funded to cheaply convert sea water to fresh water. This includes evaluation, risk/cost analyses, engineering, and prototyping (10 years).	300	382	0.68	PASS	30		49					20	3		180	100
T18	A risk/cost basis for analysis of safety and environmental regulations is developed and widely accepted for use (6 years).	100	255	0.80	PASS	10		87	100		25		10	3	20		
Life Sciences and Advanced Materials																	
T19	A joint industry-labs-university program is launched to develop home health monitoring systems (2 years).	50	0	0.13	N/A												
T20	A joint industry-labs-university program is funded to develop software for diagnosis, epidemiological studies, remote consultation and diagnosis (telemedicine), and health management, and to place these tools on the Internet with secure technology (3 years).	60	75	0.68	PASS	40							25		10		
T21	A beta version of a new telemedicine protocol is successfully tested in 10% of the US. This includes the central hardware and system-wide software and security necessary for operation (4 years).	250	0	0.18	N/A												
T22	Biomimetic materials prove to be outstanding in innovative building and manufacturing processes. NIH and NSF jointly fund research into new applications (6 years).	300	0	0.17	N/A												
T23	Research in enhanced recombinant DNA technologies increases food production by 20% in the US and by 100% in developing nations (6 years).	200	150	0.41	FAIL											100	50
T24	A joint industry-labs-university program is launched to develop smart materials for construction and manufacturing that give visible or audible warnings when they become unsafe (5 years).	100	130	0.63	FAIL				130								
T25	To improve the nation's transportation infrastructure, a joint industry-labs-university program is launched to improve the safety and durability of roads and bridges (10 years).	300	0	0.14	N/A												

National Security and Criminal Justice																	
T26	If T1 succeeds, a virtual weapons test (3-D, large mesh) is demonstrated with the 15 teraflop machine using an advanced hydrocode (4 years).	100	0	0.17	N/A												
T27	To meet the needs of a secure nuclear weapons stockpile in the absence of testing, the National Ignition Facility is approved for construction (5 years).	800	0	0.15	N/A												
T28	Accelerator-produced tritium is chosen over a new reactor (5 years).	800	0	0.18	N/A												
T29	DOE concludes agreement with the commercial nuclear reactor industry to insert tritium-producing systems into commercial reactors to provide tritium for all future wpns needs, thus no need for new accelerators or reactors for tritium production (5 years).	160	0	0.17	N/A												
T30	The DOE decides to upgrade one of its existing facilities to enhance the US neutron research capability. The DOE chooses which one (4 years).	200	0	0.15	N/A												
T31	A joint DOD-laboratory-university program develops system-level technology to detect, evaluate, and neutralize metal land mines (6 years).	100	0	0.13	N/A												
T32	A safety tracking system using an encryption chip is developed. The chip and system are to be used for shipping, materials control, and child and prisoner tracking (6 years).	150	0	0.14	N/A												
T33	A new program is launched to use the labs technology capabilities to enhance the security and safety of citizens from internal threats like crime and terrorism (10 years).	300	150	0.33	FAIL	100						50					
T34	A Disaster Minimization program is launched to explore ways to prevent or mitigate damage from natural disasters such as earthquakes, floods, and hurricanes (10 years).	400	0	0.15	N/A												
NEW TECHNOLOGY OPTIONS																	
T35	National Security labs will join with Universities, and any other Federal labs to develop a robust effort in support of nuclear power plant life extension (10 years).	30	30	0.54	FAIL	15		15									
T36	A major new program is launched to ensure the integrity and security of the global information infrastructure and telecommunications system to protect government, business, and personal transactions. (Standards, security techs, protect equities, information)	200	0	0.14	N/A												
T37	T20 modification - focus on reducing health care costs, paperwork and improving patient information and services.	70	0	0.15	N/A												
	Technology Subtotals =	**8450**	**1921**			**315**	**250**	**250**	**230**	**0**	**75**	**150**	**115**	**46**	**40**	**300**	**150**

Option Number		50% Prob. Cost	Total Invested	Total Probability	PASS or FAIL	US Congress	Ind 1 (IT/AMfg)	Ind 2 (E/E)	Ind 3 (LS/AMat)	Ind 4 (NS/CJ)	Dept. of Energy	Other Agencies	Universities	DOE NS Labs	DOE S&T Labs	Foreign	Control
	Assets available $ >>		2850			550	300	300	300	300	100	150	150	50	50	300	300
	POLICY OPTIONS																
P1	Congress decides to create a lab-closing board similar to the base closure commission.	50	0	0.15	N/A												
P2	Congress closes two national laboratories and decides on which ones.	50	0	0.14	N/A												
P3	DOE decides to create and implement a "Lead Laboratory" concept. They develop this in conjunction with the labs and propose the ideas to Congress.	50	0	0.16	N/A												
P4	DOE authorizes the creation of a "System of Labs." The labs and DOE develop and implement the concept.	100	10	0.18	N/A						10						
P5	The DOE weapons labs are placed under the Department of Defense.	100	0	0.15	N/A												
P6	Several labs are privatized. Congress, DOE, industry, and the labs decide on which ones.	50	0	0.17	N/A												
P7	The FFRDC legislation is repealed. All national labs are required to compete on an equal basis with universities and private industry, with no level-of-effort funding; all government property and infrastructure are transferred to the labs. This privatizes labs.	150	0	0.16	N/A												
P8	The non-weapons labs arecorporatized and operated by a new non-profit corporation. Funding would come by line-item through the Congressional budget.	50	0	0.15	N/A												
P9	All DOE labs are corporatized and operated by a new non-profit corporation. Funding would come by line-item through the Congressional budget.	100	0	0.18	N/A												
P10	The non-weapons labs are eliminated and all their facilities and equipment are auctioned to universities, industry and foreign governments. Lab staff are provided generous lay-off allowances based on seniority.	200	0	0.15	N/A												
P11	Congress expands the missions of some national laboratories to include two-way technology transfer (to and from industry) in a mutually beneficial process controlled and orchestrated by the labs.	100	0	0.15	N/A												
P12	Congress removes all funding for tech transfer initiatives at the labs.	50	0	0.18	N/A												
P13	The labs are assigned the responsibility for evaluating all environmental regulations to ensure that they are science-based and cost-effective.	100	0	0.18	N/A												
P14	Congress adds biotechnology as a new mission for the national labs.	100	0	0.15	N/A												

P15	Congress adds internal security and safety as a new mission for the national labs to use technology to improve all aspects of the criminal justice system: crime prevention, criminal apprehension, evidence, incarceration, etc.	100	0	0.16	N/A												
P16	Congress creates a new Department of Science that includes all science and technology R&D currently done at DOE, DOC, NSF, and other federal agencies.	100	0	0.15	N/A												
P17	The DOC is abolished.	100	0	0.14	N/A												
P18	The DOE is abolished.	100	0	0.17	N/A												
P19	DOE and DOC are combined to manage all existing responsibilities and to create synergistic facilities and programs.	100	0	0.18	N/A												
P20	Congress reduces funding to all the labs by 30% across the board over 5 years.	40	0	0.16	N/A												
P21	Congress increases non-defense R&D spending by 5% per year through the year 2000 by means of a slight tax increase .	300	0	0.17	N/A												
P22	Congress reduces non-defense R&D spending by 5% per year through the year 2000 and implements a slight tax decrease.	50	0	0.17	N/A												
P23	Congress implements sin taxes of $1 per pack of cigarettes and $1 per liter of hard liquor to increase non-defense R&D funding by 5%.	150	0	0.17	N/A												
P24	Congress increases the federal gasoline tax by $0.10 per gallon. The resulting revenue (3% increase) will fund new R&D on energy (sources, efficiency, etc.)	100	0	0.15	N/A												
P25	Congress passes legislation to remove all impediments to deployment of advanced information and telemedicine systems across state boundaries by creating a national licensing system for medicine.	200	0	0.16	N/A												
P26	Congress creates a major program to measure the results and return on investment of all government R&D programs.	100	0	0.18	N/A												
P27	Congress establishes a virtual replacement for the Office of Technology Assessment (OTA), managed by the labs, and pulling resources from universities, labs, and industry to respond quickly to Congressional questions.	50	0	0.18	N/A												
P28	Congress authorizes DOE to benchmark other national technology delivery systems and laboratory approaches(e.g.,Fraunhofer in Germany, the ministries in Japan, the 12 labs in Singapore, etc.) and report back to Congress with recommendations.	50	0	0.15	N/A												
P29	DOE and Congress develop the will and the funding to solve the nuclear waste disposal problem in 5 years.	500	0	0.17	N/A												
P30	R&D tax credit is made permanent and joint industry-national laboratory and/or university efforts are included as eligible for the credit.	50	140	0.87	PASS		50	50	40								
P31	Specific companies and the laboratories negotiate a program to create temporary assignments of lab staff to industry and vice versa. Program jointly funded by industry and DOE. Requires agreement among DOE, Industry,Cong, both	100	0	0.15	N/A												

	Labs, OFA.				
P32	Congress reforms the product liability system to create incentives for technological innovations in transportation, biomedical technologies, etc.	200	0	0.14	N/A
P33	Congress repeals the Glass-Steagall act and removes all regulatory barriers preventing banks from owning equity in companies.	100	0	0.17	N/A
P34	The Bayh-Dole Act is amended to remove giving automatic title to intellectual property to university, not-for-profit and small-business partners. However, they have the right to negotiate appropriate licenses.	50	0	0.15	N/A
P35	Congress decides that it will only fund basic research at universities or institutions managed by universities. The labs must focus only on mission-related, applied research and development.	200	0	0.13	N/A
P36	Mutual defense pacts with allies are written to include broad technology-sharing agreements. This option requires an agreement among the following teams for implementation: DOD (Other Agencies), Congress, Weapons Labs, and Foreign.	100	0	0.16	N/A
P37	The National Technology Transfer Act (including the restrictions on national labs giving intellectual property rights to foreign entities) gets amended.	50	0	0.15	N/A
P38	The Bayh-Dole Act is amended to make it consistent with the 1989 Technology Transfer Act , thereby banning universities from licensing or selling intellectual property to foreign entities.	50	0	0.14	N/A
P39	Congress authorizes DOE to work together with foreign countries, labs and universities to conduct coordinated research on global environmental problems.	100	0	0.17	N/A
P40	A new multi-stage standard setting program in created and adopted. This includes development of on-line archives and would support proposal, voting, development, and creation of new industry standards.	80	0	0.16	N/A
P41	Foreign companies acquire preferential and exclusive rights to the results of federally funded research at US universities by contributing to university facility, teaching and R&D needs to replace lost federal funds.	200	0	0.15	N/A
P42	Foreign companies create US-managed venture capital firms to obtain access and manufacturing rights to technologies developed at labs and universities.	200	0	0.14	N/A
NEW POLICY OPTIONS					
P43	Maintain a vigorous fundamental science and technology investment level at the DOE Civilian S&T labs. Annual increases in funding to maintain parity with increases at NIH and NSF.	100	0	0.14	N/A
P44	A precondition for any international agreements is honoring all IP rights and achieving parity in tariffs with strong dispute settlement at GATT and through bilateral actions.	300	0	0.18	N/A

P45	Congress requires DOE, DOD, and DOC labs to spend not less than 25% of their R&D budgets with the private sector (w/matching $).	100	170	0.86	PASS					165	5						
P46	Congress enacts a 25% flat tax credit for R&D investments in formally traceable partnerships (industry with labs, universities, or both).	100	210	0.82	PASS				30	135			35		10		
P47	Congress authorizes DOE to work together with foreign countries, labs and universities to conduct coordinated research on global environmental an educational problems.	150	0	0.14	N/A												
P48	Industry receives a tax credit for R&D they fund (through a directed grant) at either universities or national labs. Does not include partnerships. (WL)	20	14	0.41	FAIL						10			4			
P49	Nunn-Domenici tax reform. Dismantle IRS. Replace income tax with consumption-based tax to facilitate investment. Corporate tax allows for expensing of capital investment (1yr depreciation). (Congress)	450	200	0.32	N/A	100											100
	Policy Subtotals =	**5990**	**744**			**100**	**50**	**50**	**70**	**300**	**25**	**0**	**35**	**4**	**10**	**0**	**100**
	Grand Totals (Spent)=		**2665**			**415**	**300**	**300**	**300**	**300**	**100**	**150**	**150**	**50**	**50**	**300**	**250**
	Team Credits Available =					**550**	**300**	**300**	**300**	**300**	**100**	**150**	**150**	**50**	**50**	**300**	**300**

Appendix H: Analyst's Reports

(These reports have been edited by the Prosperity Games' staff)

US Congress

I. Team Members

All of the participants were eminently suited to represent Congress in this game. Five are current Congressional staff members, and were working on active legislation out-of-game hours. Three have experience in the federal legislative and/or executive branches. Most had scanned the handbook to identify selected information, but had not studied the information in detail.

Steve Clemons (Sen. Bingaman's staff)
Doug Comer (House Science Committee)
Polly Gault (Lobbyist)
Paul Gilman (National Research Council)
Randy Hyer (Sen. Domenici's staff)
Bill Triplett (Senate Staff)
Michelle Van Cleave (Attorney)
Tom Weimer (House Science Committee)
John Yochelson (Council on Competitiveness)

II. Team Composition and Preparedness

All participants had knowledge and experience in R&D policy and federal legislation. As mentioned above, the majority were also experienced in Congressional operations. Since they all were familiar with R&D policies and with Congressional procedures, their initial focus was on defining the goal of the game and clarifying their roles.

The major unique skills brought to this game by the team included:

- thorough understanding of the legislative process
- understanding and appreciation of national concerns
- knowledge of the current political currents and active legislation in related fields, e.g., tax credits for R&D
- ability to work 5+ issues simultaneously and effectively
- tremendous enthusiasm and dedication

The panel was strongly Republican. Steve Clemons pushed hard, and effectively with the Democratic views. When the debate became overbalanced, Doug Comer would take the Democratic side to provide some reality. The Republican views dominated but changes were made due to Steve's pressures.

III. Description of Planning Session

Pre-Game Collaborations

The planning process started at the supper. John Yochelson initiated the discussion by suggesting we go around the table and each person would give their background and biases in the context of the game. This was particularly effective in identifying interests and overlaps or conflicts between members. Initial discussion kept focusing on the labs. The facilitator encouraged them to look wider than the labs, to look at the US R&D needs, to develop their priorities and goals.

Subsequent discussions included the following issues:

1. R&D tax credits - general consensus that this would overwhelm all other financial issues being discussed
2. Universities provide a double hit for support - future employees as well as research
3. University research most fragmented
4. General concern that Lab research productivity was sporadic, interactions most inconsistent, perhaps not usable
5. Need to separate the three weapon labs from the other; concern is with the other labs
6. Will have universities and industry in 50 years but are the Labs a viable long range planning resource?
7. Legislation that would impact the National Labs might be in three categories: Increase efficiency by constraints; require missions; change their culture

Ground Rules

The team accepted Doug Comer's suggestion of acting as a "Committee as a Whole," i.e. being a joint committee for the Senate and the House, and acting on both appropriations and authorization legislation. All issues were discussed and to be approved by consensus. Formal votes required a majority to pass. Understanding the issues and the acceptance of individual views was deemed critical to develop exact legislative language.

Roles

In a brief discussion, they decided to identify contacts with each of the teams in the room (akin to the alignment of staff in a Congressional office) and not with the normal committee structure. The decision was partially based on the fact that the compressed time scale would not allow effective committee interactions. The desirability of using a committee structure was mentioned after the game and should be considered for future games involving Congress. No specific roles or legislative leads were identified. Each member assumed ownership of some piece of legislation, or issue and led the rest of the group in those issues. Steve, with some help from Doug, did represent the minority views which triggered debate. The impact of Republican/Democratic split was representative of the current Congress.

Challenges and Objectives

Tom Weimer noted that the prime objective of a Congressional delegate is to get reelected. That led to discussions on the need to increase the number of jobs, and to improve the quality of life. In the discussion, the team agreed on several areas:

1. R&D was important to their goals
2. The federal government was a small player in the overall R&D effort in the US
3. The National Labs were even smaller players
4. Budget was short and they would hold federal R&D spending constant
5. The main focus had to be on legislation that would encourage industry to invest in R&D, in particular in research at the universities or labs, whichever industry deemed appropriate
6. All federal laboratories must be considered, not just the national labs

At this point, Paul took the lead to get agreement on specific objectives and strategies to meet those objectives. The Republican bias was strong and Steve fought hard to include social issues. Doug switched at times to support the minority view. The specific goals were identified to be:

- To Improve the Quality of Life for All Americans
- To Maintain Our Quantitative Superiority in National Defense
- To Balance the Federal Budget by the Year 2002
- To Ensure that the United States is Globally Competitive

The group agreed on strategies to meet the goals which resulted in the following statements:

To improve the **Quality of Life**

- we will seek a robust and growing economy, and will seek to reform the tax code to increase savings rates and corporate research and development
- we will reduce the size and intrusiveness of government; regulatory reform will be a key element of this effort
- we will support research to lower the cost and improve the quality of human health, the environment, and energy supply and use
- we will seek a robust civilian R&D sector (including university, industrial and federal laboratory research) as appropriate through both monetary and non-monetary incentives

To maintain our qualitative superiority in **National Defense**

- we will support research with appropriate development
- we will support readiness
- we will support weapon systems procurement exploiting "off the shelf" commercial suppliers, and focusing federal funds on critical military capabilities
- we will support the continuation of critical science, technology and industrial base to protect against "surprises" from foreign governments

To ensure the U.S. is **Globally Competitive**

- we will support efforts to improve teaching of science, technology and mathematics
- we will seek to increase U.S. corporate sales overseas, oppose protectionist trade policies by others, protect intellectual property rights internationally, and protect against foreign trade espionage
- we will modify antitrust policy in ways to promote U.S. R&D collaborations

The overarching strategy was then selected to develop legislation that would improve each of the goals and the strategic objectives listed above using the previously discussed considerations. This strategy in general was to provide incentives for industry to invest in research with further incentives to support work in universities, and possibly federal laboratories.

Communication was identified as a key part of the strategy in order to get the laws implemented and also get support of the US citizens, industries, universities, and laboratories. Communication mechanisms included:

- Use the press and other media extensively
  - Initial press release on Goals
  - Press releases throughout the process including one on each of the 13 bills passed
- Randy became our "Newt Gingrich," announcing actions of Congress. (Discussion at the table by the other staffers is that his actions were most real, i.e. many words, can't really figure out what they mean, most people do not listen.)
- Strong interactions with the press

IV. Strategy Implementation

Session 2: Congressional roles in the Toolkit negotiations were not clear. President Berman assured Congress that should legislative issues be enacted in the Toolkit (a

Congressional role), Congress could repeal or change them in subsequent actions. The President subsequently told an upset Congress that the tax law passed in the Toolkit had been done in the past administration. Congress could modify that law in the next fiscal year.

Session 3: The team rapidly concluded that their biggest impact would be on a tax package. Polly chased down the question of what the existing (Toolkit) tax actually meant and how it should be changed. Michelle kept bringing the discussion back to a focus that would impact our goals. Randy introduced the "Nunn-Domenici" bill (would supersede the tool kit established bill), Steve added a bill to prevent R&D money from going to foreign countries.

Several members noted that we did not get much action from the other sectors, possibly because they perceived we did not have money (we did not have much). Steve, serving his Democratic role, then publicly announced that Congress had money ($31M). Interest from the other groups picked up rapidly.

Cost reduction bills were introduced by Doug to privatize the DOE research labs, and by Steve to combine several agencies involved in economics into the Department of Economic Security (list of proposed agencies debated and modified). Both passed and were signed. Michelle led a hearing with Other Federal Agencies on enhancing the security of our citizens against internal threats. This resulted in a National Terrorism Bill that passed.

Paul Robinson, Defense Labs, met with the committee to request support for the national computing initiative. The pervasive argument that this was strongly supported by industry led to the response that then the federal government support should not be needed. However Congress provided minimum funds to show their support, and also passed a new law, The National Computing Initiative.

The universities requested support for their Genome project. Universities were asked to get industrial funding and subsequently Congress would invest in their proposal. Congress added money to NSF.

During this session, Michelle, Paul and Tom would recognize that constituent pressures were preventing us from meeting our Congressional goals, so we had to have some closed hearings and short recesses.

Session 4: China invades Taiwan islands. Randy orates that Congress will not tolerate this invasion. (Paul asks the team, "What is he talking about ?") Debate on what to do includes a blockade, give Taiwan more sophisticated weapons, freeze assets, "drop the big one," etc. The debate obviously alienated the Foreign team, particularly following on previous discussions where Congress ignored their lobbying.

Note: This event caused a problem in the game as it was played. Congressional reactions were real. Congress felt that a State Department role or intelligence from one of the agencies would have provided warning to the impending events. But the President did not push the State Department, CIA, etc. into the fray to provide the buffer between Congress and China. In hindsight, we should have gone to Other Federal Agencies and demanded that the CIA provide intelligence, and the State and Defense Departments list options.

Also the question came up about how to react in this game since we were focusing on R&D and had neither the structure nor the time to take on other national issues. In addition, the other sectors paid little attention to the problem and continued to approach Congress for support of their issues. Congress held a hearing on DOE plans for downsizing, privatization, etc. A straw vote endorsing the plans narrowly passed.

Recess - Status of meeting goals discussion. Also debate on how to get money to support actions against China. Proposals included selling ANWAR, selling federal lands or facilities, a sin or gasoline tax, tax on chocolate cake. Debate led to a consensus that we would not raise taxes. The discussion led to balancing the budget.

In year 2000, where we are now, entitlements are broke. Tom and Paul develop legislation, Steve protects citizen interests, legislation passes. President says this is included in the game design and does not sign.

Note: We did not study the budget projections in detail, but the balanced budget was already built into the game. The team had not recognized that fact (fault of analyst) and expended considerable energy in developing a bill.

Steve got his Corporate Team Act passed. The act amended antitrust legislation to allow industry collaboration with government involvement through the new Department of Economic Security.

Recess: Refocus on what has been done and still needs be done to encourage industry. Congress recognizes they need to ask industry and set up some hearings. John emphasized the need to get a statement from the R&D community on their metrics (since it is year 2002), and understand the current state of the federal labs. It's not clear how to do all this.

National R&D Summit Meeting: Although the Summit Meeting is in progress, budget pressures do not allow this Congress to attend or conduct any long range planning. Congress meets separately with OMB on budget details and with the Administration on the demolition of DOE. Constituent groups continue to approach Congressional members during the Summit. Tom calls for a special hearing with DOE and its Labs to review their current status. Doug represents Congress at the Summit.

Session 5: Hearing is held with DOE and its labs. In response to a law passed 5 years ago, DOE has developed a plan for downsizing. Congressmen John and Doug asked why it has taken DOE five years to take action, and why should Congress expect any further action no matter what plan was presented. Randy asked why DOE had not taken the initiative to provide any information to Congress on their actions in the past five years. DOE responded that they had gone to the labs, but the labs had never responded. Limited rationale provided by DOE. Presentations were made by DOE and a representative each from the DOE/DP and ER labs. Discussions were highly interactive with all the Congressional members. Discussions included questions about the focus on DOE rather than the some 650 or 720 federal labs, the diversity of work among the DOE labs, the need for the three DOE defense labs, increasing concerns of terrorism, ES&H costs etc. Congress was not impressed since there had been time to correct many of the problems, and no progress had been made.

Hearing with industry (Industry 4) on possible acquisition of one of the defense labs. Polly kept pushing on the lab rationale to keep all three labs asking if the need was justified since the cessation of nuclear testing. A motion was made to close one defense lab, discussed and withdrawn. Bills to identify and sell excess facilities, and to institute a Lab Closing Commission passed. DOE was also provided funding to accelerate the privatization of some labs.

On request, the President appointed a commission to review the needs for federal labs. Polly, Tom and Randy are appointed to the commission. Their studies conclude that there should be a 20% reduction in the number of all federal R&D labs.

Constituent pressures increased as this Congress came to an end. Most not acted on due to lack of time, and the need to develop the legislative strategies if they wanted to act. Suggestions were made to slip in riders. We will have to wait to see if some did get slipped in when the final bills are reported out and implementation starts.

V. Level of Strategic Planning

Early establishment of the goals, the metrics and assignments provided the basis for effective interactions. Strategies were followed using consensus, but also involving extensive trust in recommendations by other members. The lead would move around the table continuously as one or another of the team members promoted legislation.

The interactions were most creative - Congress identified, developed, discussed, wrote, and passed some 13 laws and held several hearings.

The strategic plan to meet their goals was simple but effective. Paul, Doug, Tom, and Polly stopped action at times during the game to pull the effort back to the strategic plan. Communication strategies were followed but considered by the team to have been unsatisfactory (but perhaps real). The team realized that the press conference material should have been documented and provided to each team in addition to the verbal announcements.

VI. Team Dynamics

The players focused on their identified contact groups, but had no hesitation in helping other team members when needed. As actions were defined, the person responsible for the issue reviewed that with the team and then led the decision process. This usually included a discussion followed by consensus, or a vote. Actions focused on the Congressional goals.

Individual roles were not formally identified but more or less assumed by individuals and accepted by the others. Paul Gilman took the big view, kept pulling things back to the four goals, asking how legislation would impact those goals. He had led the group in identifying the initial goals and objectives.

Tom Weimer quietly worked the details of the legislation, working closely with Paul to develop a strategy for meeting their goals with visible results, e.g. decrease in national debt, increase in standard of living etc. Doug Comer and Steve Clemons actively wrote legislation. Steve had many debates to include the Democratic issues in the final legislation. Randy Hyer assumed the lead in communications with radio announcements and press releases. Michelle Van Cleave led the defense effort, making sure that the legislation would also enhance the U.S. defense posture with a focus on industry support. John Yochelson kept bringing in the industry perspective, emphasizing the need for metrics on R&D and a show of value added to the industry. Polly did much interfacing with other groups and was key in maintaining team enthusiasm, as well as focus on the defense issues.

When things got over hectic, the facilitator would suggest a time out. Congress would then call for a recess, or for closed hearings. This worked. In the recesses, the team would debate issues and come to a consensus. They would also review their priorities and changes needed to continue the focus. This process was effective as evidenced by the passage of some 13 laws and impacting the metrics of the game.

VII. Team Successes and Failures

Successes

1. Defined, developed and met all goals
2. Activities had a positive impact on all aspects of the US economy
3. Passed 13 laws, all focused on meeting the proposed goals
4. Realistic
5. Legislation Enacted (listed in chronological order)
   - Tax Reform
   - DOE Restructuring
   - Critical Industry Preservation Act
   - American Economic Competitiveness Act
   - Anti-Terrorism Act
   - Corporate Teaming Act
   - ANWAR Access Act
   - Entitlement Control Act
   - Flat Tax, R&D 15% Credit for Collaboration
   - Intellectual Property Reform
   - Federal Laboratory Closure Commission
   - Excess DOE Facilities Sales Enablement Act
   - FDA Reform
6. Maintained focus on goals and used the strategy throughout the game
7. Avoided war - "Peace through Strength" (Polly)
8. Had $10M excess at end of game, reduce national debt or party ?
9. "Are you better off now than you were three days ago?" "Absolutely !!!!!"

Failures

1. Although did extensive communication, did not get messages across as effectively as needed. Propose written news releases on each bill passed by Congress to be handed to each of the teams.
2. Did not understand the boundary conditions related to the federal budget. We wasted much time trying to balance the budget when it was balanced by definition. Balanced budget assumptions seemed unrealistic to the team.
3. Congressional team should have built hearings and recesses into their initial strategy. Although there were several hearings, industry and others felt they could not interact with Congress. Also Other Federal Agencies were constrained from addressing Congress since they cannot lobby, or appear to be lobbying.
4. Other sector reports that Congressional members were: war mongers, anti global, did not approach customers, did not partner, ineffective at passing legislation, stopped positive changes in partnerships, etc.
5. Needed to include a State Department or intelligence function to warn Congress of impending China action. Congress was taken by surprise and felt it was unrealistic.

VIII. Suggested Follow-on Activities

The game enhanced awareness of the importance of R&D, and particularly the overwhelming role of U.S. Industry. The legislative concern then is to encourage industry to invest in research. A portion of that investment must be focused on non-directed or basic research which will not impact the bottom line in the next quarter. In addition, legislation should assure that industry works closely with universities and the laboratories to utilize the synergism of the various capabilities, and to make research cost effective. Metrics need to be established to understand the value added of research, and consequently to provide a basis for research planning.

Consequently, follow on activities are needed to:

1. Identify legislative initiatives that will assure industry looks to the future, and involves the universities and federal laboratories in research as appropriate;
2. Develop metrics needed to measure research performance;
3. Identify the optimum investment of federal R&D resources to enhance the value of life in the US recognizing the federal investment is small compared to that of Industry;
4. Assure that federal investments in research benefit s US and not foreign industries, and the results add jobs in this country;
5. Eliminate duplication of efforts in the many federal R&D laboratories and focus the federal efforts.

Proposals to pursue these activities include the following :

- National R&D Summit Meeting (This follow on meeting will focus on US R&D policy ; it must be organized and run by a non-partisan group, e.g. Council on Competitiveness (John Yochelson, Champion) or National Research Council (Paul Gilman, Champion). Congressional members must be stakeholders, but not dominate.)

- Report from this game - briefed by the National Lab Directors to their staffs (Lab Directors & Advisory Boards, Champion)
- Develop R&D Metrics - critical to demonstrate value to industry, government, and taxpayers (John Yochelson, Champion, Council on Competitiveness, or National Research Council)
- Enhance Congressional communication with U.S. industry advisory groups and Professional & Trade societies
- Technology Partnership Roadmap pertaining to national R&D policy
- Create teaming advisory groups to break barriers between Labs, and between Labs and industry
- Develop an S&T advocacy for the general public
- Repeat this game, i.e. R&D in one year ; include OSTP or administration players (perhaps on control team)
- Follow on "Newsletter(s)" to all participants on the status of implementation of the game results.
- All Congress Team members with the exception of Triplett willing to support follow-on activities and desire a copy of the final report for their information.

Note: A number of these activities could be done in a Prosperity Game format.

US Industry 1: Information Technology and Advanced Manufacturing (IT/AMfg)

I. Team Members

Patrick Arnone, Sybase, Inc.
Wilmer (Bill) Bottoms, Patricof & Company
David Chew
Richard (Dick) Jarman, Eastman Kodak Company
John Strothman, Strothman & Associates
Jack Swindle, Texas Instruments
Deborah Wince-Smith, Council on Competitiveness

II. Team Composition and Preparedness

The team had all read the handbook and were familiar with the challenges. One player encouraged us to base our strategic planning on the metrics in the handbook.

The team requested thorough interviewing during dinner to better determine the strengths of their team. These interviews revealed a very diverse group including the strategy and execution sides of manufacturing, government, hardware and software development and application, IT, industry, NIST, banking and change management. There was some knowledge lacking in the role of the national labs as possible collaborator in IT and AM. Deborah gave an overview of current lab initiatives with industry and identified key terms. Questions were explored such as “How much is industry already funding labs?” “How many dollars are generated from CRADA’s products?” “What share of collaborative research do labs own (vs. universities)?” The team knew it would have to partner with both labs and universities.

III. Description of Planning Session

The team had two individuals intent on process skills necessary for success strategically . Focus and accountability needed to be strictly controlled and roles clearly defined; a quick consensus was to be used for decision making. Others wanted to immediately begin looking at Toolkits. A compromise occurred and the team brainstormed for 30 minutes on “Who are we.” This resulted in the following approximation to be more clearly defined the next day.

They decided their **objective** would be to maintain and increase the competitiveness of the US IT/AM industry; to work with a clearinghouse of labs, universities and countries; they saw the labs as co-developers, not customers. We want to increase (maintain) worldwide market share. The big question is “How far can we predict?” IT - 5 years (controversial) even Bill Gates would be foolish to predict further. AM - 5 years for sure.

They stated that over the next 10 years their biggest challenge and opportunity would be education. Despite stating this, it was not discussed during the rest of the game.

The team found it difficult to spend time on creating strategies. Instead of continuing to move toward a unified vision and challenge, the team opted to evaluate the Toolkit options, relying on the resulting discussion to further solidify our challenges. Each Toolkit was given a +, -, 0 (neutral) with some discussion on each. This exercise provided a clearer picture of the markets the team might address. The Toolkit provided a springboard for the early stages of strategic planning.

Another discussion that further encouraged strategic planning was answering the questions "What is the worst that can happen to our industry?" The team noted that war is NOT a threat. The following threats are: massive piracy, restricted access to other markets, currency fluctuation, Buchanan nativism, product liability, and access to competitive low-cost capital. The team will consider ways to offset these threats by lobbying and collaborating with other teams.

The following goal, vision, and initiatives were agreed upon:

Goal: Drive down the cost of computing and communication to increase global consumption of these items and do so on an internationally level playing field with proprietary access. Utilize the increased sales to further drive down production costs.

Vision: Industry 1 team is a global source of technology tools. Seen as "tool providers." The industry provides the tools and encourages new business applications. "Everybody is our customer" is possible as we see that all other groups need the industry in one way or another. The industry offers processes, design, simulation, emulation, and algorithms.

Initiative 1: Telemedicine; leveraging the $100 billion healthcare industry. This initiative partners on 1) security; 2) database management; 3) multi-platforms, 4) two way. These will be in the form of contracts for a royalty stream from transactions.

Initiative 2: "Smart houses"; energy efficiency and security for homes, factories and business. Will reduce energy costs globally 25% -- high quality security services. The Industry will receive 10% of the savings.

Initiative 3: Transportation; initial move is to build high-speed mass transit to serve high density quarter. With a 30% internal rate of return, this initiative will decrease traffic, decrease environmental damage, at high speed/low cost. First step is to take over and modernize east coast roads.

Initiative 4: Coordinated development of operational desalination plants.

Initiative 5: Intelligent transportation. Global consortia for smart mass transit offered to emerging countries (build on initiative 3). Initial funding of technology must be done in 18 months to take advantage of Congress' new incentive.

IV. Strategy Implementation

The agreements negotiated with other teams were based on the desire for Industry #1 team to drive major national initiatives, test beds using advanced information technology for health, transportation, security, education, and globally move into new markets. At the beginning of the afternoon session the team decided the 1998 objective wa s to impact growth areas only.

Industry #1 did not want to drive the mission statement of the labs. The team wanted to use the labs as "spot solutions" rather than part of a grand scheme. They asked the question, "Do we care about the well-being of the labs?" Answer -- "neutral." If the labs pay for the development of the technology (e.g. teraflops) we can use it, but we want to see ongoing demonstrations of competency from them.

Their discussion on process vs. products resulted in the conclusion that it is so hard to predict product in our industry - we can barely look past 5 years. So they have to focus on process.

- US Industry 1 team only needed to partner for bigger leverage. As a big industry, team felt they could have succeeded by themselves.
- Pushed authority down to the execution level with John as focal point. Execution mechanism.
- Team kept being pulled to quantitative discussions on our investments and ROI and probabilities. The team also challenged and checked their results with Control team to make sure it was accurate. Get measured by results, compensated by results, so the team insisted on spending time calculating results.
- Foreign teams not adversarial - team made an effort to attend to them.
- The labs never came to the team with a vision - very narrow-scope material.
- Best ideas; T1 and T5 (the team favorite). Telemedicine, micro-manufacturing, information surety, sensors, mass transit. Transit system is big customer for our industry. "If you build it, they will come", not necessarily the case. Rapid rail, etc. needs marketing.

V. Level of Strategic Planning

At the beginning of session 5 two members wanted to move up and build on previous successes, but the rest of the team was "seize the day." The comment was made that they had been shooting for too low an ROI; discovered today they could go for a much higher ROI.

- Shortcomings of team: underestimated ROI that Control team would accept; underestimated telemedicine; weren't as fast off the mark as they should have been, especially Session 3; started off slow, but momentum built; didn't feel like it was possible for them to look 20 years out.

- Settled on driving and enabling technology, rather than the big computer.
- Much of the team's "seize the day" strategy resulted from not understanding the ROI.
- No incentive to go to higher vision. Team didn't stretch far enough. The game forced the team back into something quantifiable. No incentive to build it to a higher program. The team took some 30% ROI when there was 100% ROI out there that team didn't find. Congress provided no incentive for team to go further.
- Team was never forced to change their strategy.

VI. Team Dynamics

One player felt the team needed to spend some more time talking about the Toolkit options. He said that out of the Toolkit process the team should be able to go forward. He wanted to use the Toolkit through all of the strategic planning. Another player felt the team didn't have a vision yet that could drive their decisions for the Toolkit options. The team decided to go back over the Toolkit and talk about the three most important things to them. The team came to the conclusion they needed to partner with the universities on the ASCI option and needed to look at the partnership issues. T1 and T5 were of the top importance.

A lengthy discussion was held in the area of telemedicine. According to one of the team members the amount of money in telemedicine is peanuts and healthcare is not a big user in advanced manufacturing. A big discussion followed between two team members in the area of telemedicine. One member had no interest in it saying people want a human being treating them and felt it is a big waste of money; the other member was a firm believer in telemedicine.

The team spent a great deal of time just discussing and as a result they ended up just sitting around waiting for everything to fall in their lap, yet when it does they drag their feet and still end up losing on the deals (e.g. telemedicine).

After the afternoon break, the team had to this time not initiated any agreements. They had only invested in other agreements, initiated by other people. The team always wants to be the last to contribute so consequently have lost out on other initiatives because of this.

The team is mainly interested in what their return on investment is; bottom line profit. Don't particularly care about any social issues -- only money. They didn't want to take risks or chances, but only wanted to go with sure things. The team is finding out that long-term commitments are not necessarily good for industry based on the amount of money they invested in the battery agreement with Industry 2.
Industry #1 submitted the following question for the summit meeting: "How is information technology transforming the world?"

At the conclusion of the summit meeting the team discovered that they were running out of time fast. At this point the pace turned very hectic. The team spread out to tackle individual tasks.

The team learned the key to success is understanding the other party's view of your own self-interest. They also felt they attempted to strive higher but that the game forced them back.

VII. Team Successes and Failures

SUCCESS:

- Leverage our ROI and reduce our risks
- Success in partnering is understanding the others' point of view
- Priority on quick decisions
- 80% agenda/solution
- Key focal point for quantitative info

FAILURE:

- Underestimated Control team: ROI
- We could have moved faster off the mark
- 20-year scenario - possible?
- We settled on driving and enabling strategy

VIII. Suggested Follow-on Activities

- Maintaining and improving links; making contacts individually within industry
- Who is responsible to continue efforts? Labs must continually demonstrate their capabilities
- Industry will continue to come to these functions if they are asked to participate, but it has to be made easy
- Need someone representing labor in follow-up activities
- Personal networking

US Industry 2: Energy and Environment (E/E)

I. Team Members

Mark Crawford	New Technology Week
Robert Hirsch	E-TEC
Fred Johnson	E.S.R.C., Inc./S.F.T., Inc.
Milton Klein	Milton Klein & Associates
Aris Melissaratos	Westinghouse Electric Corp.
William Powers	Ford Motor Company
Gerald Swiggett	SAIC
Joel Weiss	Lockheed Martin E/E Sector

II. Team Composition and Preparedness

Each of the team members arrived ready to play, and each of them had read the Players' Handbook. When asked if there were any clarifications required after having read the Handbook, no significant issues were raised. As we got into the game, issues of clarification would arise that could generally be answered on the spot or quickly by Control. The understanding of the Handbook by the team members was certainly adequate to begin playing the game. Each of the team members was present at the inbriefing dinner, and all stayed for the entire game except for Joel Weiss who had to miss the last day.

The industry challenges were discussed in a general manner, but the team did not choose to go through them one-by-one or in any great detail. The time horizon of the next 10-20 years was discussed in the context of the session time frames, for example, but not as a specific orderly discussion of the challenges. Also, all of the players were familiar with at least one of the DOE National Labs from some relatively close association (advisory board member, part of an M&O team, consultant, ...), and therefore issues like lab competencies, competition with the private sector, or protecting proprietary information were not explicitly discussed. The primary discussion from the challenges that the team focused on was the R&D required by their industry over the next decade or two.

From a skills and knowledge perspective, all of the team members had many years of experience in some aspect of energy and environmental issues. The team was diverse in the sense that many different energy areas were represented: oil and gas, transportation, nuclear power, solar, ... No one on the team chose to focus on specific environmental issues, e.g. waste remediation, except as a necessary concern that must be considered as a part of the energy generation and use for any particular energy industry segment.

III. Description of Planning Session

The team decided that since they represented several energy segments and there were too many segments to split out individually, they would represent the energy industry as a whole. No specific structure, such as an industry association or consortium, was defined. No specific environmental business or segment was considered.

The team decided to have a CFO (Bill Powers), a Home Table coordinator (Aris Melissaratos), a Toolkit coordinator (Joel Weiss), an agreement coordinator (Bill Powers), and negotiating teams would be defined on an ad-hoc basis as required. Bill Powers as the CFO/Agreements coordinator became the de facto Home Table coordinator with Aris available as a backup if needed. Decisions would be made by a quorum of 3 or more team members. Although consensus decisions would be the goal, a majority vote would be used if necessary in the interest of time and pursuit of goals. During Session 1, the team defined:

Enduring E&E Industry Objective:

- Provide adequate energy for society at a reasonable cost to society in an environmentally sound manner.

Current State (next 10-20 years):

- Aging base load generation (50% coal, 20% nuclear, ..)
- Nuclear plants have at most a 20 year life (*ed. Note: actually 40 years*)
- 50% of oil is imported, percentage rising to 60% by 2000
- 50% of all oil consumed is used in transportation
- We are in a deregulation mode
- Foreign competition is growing
- Transient environmental regulatory environment
- Weakening domestic oil/gas sector
- Global warming concerns increasing
- Big oil is profitable; Auto is profitable
- Utilities are financially pressed

Assumptions:

- Increased tension in world oil markets
- Asia will represent huge consumption market
- 50% of nuclear plants targeted for decommissioning within next 20 years
- Demand for oil will increase significantly
- 30-50% increase in number of autos worldwide
- Today with gasoline at $4-5/gal, electric has lower lifetime cost
- US will have lower energy costs than other developed countries
- New nuclear power will not impact energy supply in the US in 1-20 year time frame

- Environmental regulation will increase but at a slow rate
- There will be a military conflict that may influence US energy supply

Objectives (10-20 year time frame)

- Growing profitability
- Maintain/improve environmental balance
- Be a strong global competitor
- Improve corporate citizenship image
- Be a global technical leader (including longer than 20 year time frame)
- Maintain or enhance industry political influence
- Level playing field in foreign competition

Strategies:

- Market decides technology winners/losers
- Industry funds short/intermediate term R&D
- Government funds long term/high risk R&D in subjects of national interest
- Government funds basic R&D
- Robust leveraging strategy for technology coverage

IV. Strategy Implementation

The Toolkit discussions were focused on the Energy and Environment options and the Policy options. No other category of options were initially considered, and no new investment options were formulated, primarily because of the time constraints. The E&E options were rated high, medium, and low in investment interest. Some policy options were also supported. It was also decided that, if necessary, funding against Policy options P41 and P42 would be authorized.

After normal negotiating sessions with other teams and information collection to see how they were spending their Toolkit assets, the team settled on spreading their investment where all investments were shared funding with other teams. A high priority, but expensive, option was dropped due to a lack of attracting partners. Toward the end of the Toolkit session, the team had been successful in getting partners for its high priority items, and they used the freed assets to support two other options because they were globally important (not just to E&E) and had many partners with enough dollars for high probability of success. The team was satisfied that they had accomplished their primary industry priorities and still had been able to make "public good" investments.

To lay the groundwork for the rest of the sessions, in session 3 the team brainstormed 18 different technologies for which they wanted R&D funding. By a voting and prioritization scheme, they established their initial top six priorities for the first round of negotiations (some target partners; negotiators):

1. Improved portable energy sources (Industry teams 3,1,4; Bill and Joel)
2. Enhanced in-situ remediation for hydrocarbons, heavy metals, and radioactive material (Other Federal Agencies; Jerry and John)
3. Improved fossil plant (coal and gas) efficiency and environmental results (Science and Technology Labs; Aris)
4. Advanced nuclear cycles (DOE Labs; Milt)
5. Hi-temperature materials (Industry teams 1,3 and all DOE Labs; Mark)
6. Deep water oil/gas technology (DOE Labs and Univ.; Bob)

The team defined initial dollar allocations to each of the negotiating teams but held about $35-40M in reserves for the first round. The nature of the energy industry forces the team investments to focus on the longer term since these are very long time scale, enduring issues. As new funding was obtained in sessions 4 and 5, focus was still maintained on the top six items above. When those high priority items were achieved or nearly achieved, the team returned to their initial technology list and added technology items:

7. Transportation systems simulation and modeling (all other teams; John)
8. Smart buildings

The agreements sought were carefully constructed to achieve a high return on investment and to have enough funding (typically two times the 50% probability of success) to succeed.

They did not see DOE as much of a factor in the energy industry. Nearly all of the really useful R&D would be done by the industry itself, only drawing on Universities and the National Labs when they truly had direct technology or expertise to contribute. The team did not want any more major government directed energy programs (e.g., solar, synfuels, coal gasification, ...). Their strategies listed above describe their desires in energy R&D.

V. Level of Strategic Planning

The initial level of planning dealt with identifying the longer term issues in the energy industry. The plan was based on the facts of today and tomorrow, and concentrated in areas of high financial payback or necessary technology leadership. Since so many segments exist in this huge industry and the team chose to represent the entire industry, the priority R&D technologies attempted to touch all major segments. The R&D projects pursued generally supported the industry objectives listed in section III. No quick, easy-to-reach agreements were sought. The plan was generally long-term focused, driven by the need to be profitable and globally competitive, and had both serial and parallel aspects. The team doggedly stuck to their initial high priority items until they could make them happen, and then moved on to new issues.

VI. Team Dynamics

The team relatively quickly agreed to work in a "team decision-making" mode. Consensus was sought but a three-or-more quorum could make a decision or approve an agreement subject only to the CFO's concurrence that the team finances were sufficient. The players recognized the specialty technical expertise of each other. The negotiating teams or individuals were tasked by the team to get the agreements in their specialty or interest areas. The dealmaking was a purely parallel process. Respondents to the approaches of other teams or to conferences were chosen based on availability and area of interest. This was an independent team that knew where they wanted to invest in R&D.

Once the team had voted on priorities for agreements, they got on with the task of making it happen in a relatively focused manner. One player was discouraged that his priority item was not seen as high enough in priority by other team members in the initial selection. He dropped out of the game for a short period of time, but soon returned to help in the negotiations on the priority items and was eventually able to get an agreement on his high priority item in the second tier of agreements.

By the end of session 4, several of the team members were becoming negative and concerned over the quality of the agreements that other teams were proposing and the very high ROI that Control was allowing on agreements. They felt that many of the proposed agreements made no business and/or technical sense, and that many agreements proposed were so divorced from reality as to be ludicrous. Several proposed agreements from other teams were summarily rejected on either technical or financial grounds, and it became a ground rule to have a defined ROI before the team would consider the deal. Since nearly all of their high priority agreements had been completed or were nearly completed by the end of session 4, during session 5 the team moved to the strategy of simply looking for deals to invest in that had the highest possible ROI. By then there was considerable cynicism toward the fidelity of the money distribution and agreements quality in the game.

VII. Team Successes and Failures

The team had worked very diligently to define their highest priority R&D projects, and to make sure they had at least twice the 50% probability of success funding before submitting the agreement to Control for the success/fail determination. Three of their six priority agreements failed on the first success/fail determination, which while statistically possible seemed unlikely. That was very discouraging to the team. They found out that by adding more money to the agreement and re-submitting, a new "roll-of-the-dice" was possible (that was not explained in the Players' Handbook and seemed an ad-hoc addition). The re-submission was done, and all three failed agreements eventually were successful. This provided further skepticism of the game process, but they moved on to participate in at least two more successful agreements, again focusing almost completely on the agreement ROI by the end of the game.

They were confident that the strategy and subsequent R&D projects they had defined were the best investments for their industry. The disillusionment with financial and agreements fidelity in the game took a significant edge off what they felt was otherwise a useful experience.

VIII. Suggested Follow-on Activities

Finally, when the team was asked if they would play this game again if structured in the same way, the answer was a unanimous "no". When asked if the game could be restructured to make it worthwhile to play, the answer was "yes".

US Industry 3: Life Sciences and Advanced Materials

I. Team Members

Jim Anderson, Ford
Peter Boer, Tiger Scientific
Sam Bonanno, Foamex
Mike Cummins, NCMS
Roger Kisner, Lockheed Martin Energy Research
Tom Morjig, Catalytica

II. Team Composition and Preparedness

Most, if not all, of the team members said they had read the handbook and they seemed to be familiar with the game and the rules, although there were some specific questions about the details. The facilitator reviewed the rules and answered specific questions. The team then introduced themselves - who they were, their organizations, what they did, their interests, and how they got involved with the game. (Note: None of the members were comfortable enough with the life sciences/health care area to give it much of a focus. To provide the desired level of focus the team should have either had several health care people (physicians, medical researchers, or medical device manufacturers) -- at least two to provide a critical mass -- or there should have been a separate health care team.)

III. Description of Planning Session

Two general goals (but not the only ones) were profitability and market share, but only in certain markets (especially emerging ones). One member made the explicit point (which the staff supported) that the survival of either the labs or DOE was not a goal. The CEOs of global companies (who may not be US citizens) did not care about such survival unless the labs provided them with some value. Providing that value was a lab problem, not an industry problem. As global companies they would use the resources they needed, wherever those resources were located.

The basic sequence the team went through to get at goals and objectives was to identify the constituencies they should represent. The specific areas of interest to those constituencies were then listed and then consolidated into five major thrust areas:

1. New structural materials (for buildings, roads, bridges, aerospace)
   - Tax credits for development efforts
   - Rationalize building codes and safety regs
   - Development of new manufacturing processes (cost reduction, new uses for old materials
   - Development of high temp composites
   - Development of ultra lightweight materials
   - Development of intelligent materials
2. High energy batteries
   - SuperSkooter
   - Development of applications for consumer electronics (batteries that last longer and are rechargeable)
   - Development of applications for automotive industry
3. Superconducting wire (for power, mass transit)
   - Development of ambient temperature superconducting materials
   - Develop acceptable physical properties
   - Develop materials with clear cost benefits
   - Develop manufacturing processes
   - Establish market priorities and potential (electric transmission, motors, shielding, electronics)
4. Recycle/Reuse - especially for polymers, reinforced composites and a national distribution system for scrap materials
   - Develop identification and source networks
   - Development of purification methods
   - Development of capability to identify material constituents and sort
   - Encourage government regs to force recycle/reuse
   - Develop infrastructure to support recycle/reuse
   - Promote/develop end use products
5. Biomedical materials (artificial pancreas and injectable materials)
   - Develop safe materials
   - Develop structural materials
   - Reform product liability laws
   - Develop smart materials
   - Improve the function of artificial biological materials
   - Speed approval process
   - Computer modeling to accomplish all of the above

The team chose to emphasize the materials aspect of their charter. Based on their own experiences, they selected foams, structural materials, and processes. They also included biological materials, especially for medical devices and injectable materials, but only because it was in their team name. None of the members were comfortable enough with the life sciences/health care area to give it much of a focus. This created some conflict with other teams that wanted to focus more on health care but could not get much support.

IV. Strategy Implementation

Once the team chose the materials focus, they stayed with it consistently throughout the game. Almost all of their deals involved extensive teaming. There was little direct competition with other teams, but some frustration when they discovered another team trying to develop an overlapping deal independently.

More specifically, they see themselves as materials suppliers to other industries, not as producers of products for end users or consumers. They picked up on the facilitator's comment that the results should not be just financial but should also consider how well you accomplished your objectives. In fact, they rejected several deals with comments like, "it's got a good ROI, but it doesn't fit our objectives." Most of the deals they made had a clear materials focus, although the deal itself may have had another focus. For example, they teamed on an energy efficient vehicle because it needed lightweight structural materials and batteries. Toward the end of the game, they broadened their interests in the health care area and joined some telemedicine deals, partly because of all the complaints they had received about ignoring health care. In fact, they even borrowed to participate in one health care deal. (One of their complaints was that they did not realize until the end that there was a banking function and they could borrow for additional funding.) However, they did this unofficially with another industry team who would provide $60M for a project in session 4 in return for a commitment to give them $70M for one of their projects in session 5. As things evolved the deal was reversed and we actually provided the $60M in session 4 and got the $70M in the next session.

V. Level of Strategic Planning

The team was probably at level 2 (connected, but not individually sufficient agreements). Although some of the deals were made opportunistically, it was within the context of a well-defined set of objectives or goals. In most cases, the approach was, given a certain objective, what type of programs do we need and who can we team with. The team tended to focus on some goals in one session and other goals in the next session, although if another team proposed an extension or follow-on to something they had already done, they would support it if they had the money.

VI. Team Dynamics

Once the thrusts were identified and agreed to , the team essentially split into two groups that operated relatively independently until the second day. This split occurred partly because of different interests of the team members and partly because of personalities.

The split was 2 and 4 (persons), so the dollars were allocated as $50M and $100M. The subgroups kept within their dollar constraints so no conflict arose there, but to make sure and keep the peace , the facilitator kept the money and gave it out only when deals were finalized. Also the facilitator would not give any of money to the two - person group until one member of the other "faction" had ok'ed the expenditure.

By the end of the first day and the start of the second day , the split seemed to heal and the group started working as a single team rather than two teams.

In general, there was little interaction with the foreign team, especially after they reneged or back out of a deal. However, it was really a misunderstanding which the team was careful to avoid after that in all of their other deals. The foreign team's position was that if I4 got $300M they would contribute $50M to take the total to $350M. I4's interpretation was that if they got $250M, the foreign team would contribute $50M to provide a total of $300M.

VII. Team Successes and Failures

- Worked as team
- Willing to take bold risk
- Proactive
- Produced high quality proposals

VIII. Suggested Follow-on Activities

Several interesting lessons were mentioned in Session 6. The NCMS person said that in the past his focus had been on alliances with manufacturing companies, but now he sees the possibilities of much broader alliances, such as suppliers, labs, universities, etc., although the alliance would still address manufacturing processes. Another team member said that over the next 18 months, his company was going to build a new plant. His normal approach would be to go to state and local governments to see what incentives they would provide. After the game, his search for incentives and teaming would be much broader -- e.g. , major suppliers and customers and possible joint ownership and/or funding.

Additional potential follow-on activities mentioned by the team were:

- Newsletter
- Technology roadmaps (recognized that there is a problem between generic and proprietary research and need to pay attention to the players and their resource capabilities). Need to have technical and market participation in roadmap development
- Summits. The participation of the team in the summit would depend on agenda and level of participation of the other attendees (In other words, the president of Foamex isn't going to attend a meeting where the reps of other companies are dept. heads and government is only represented by low-level people.)
- Industry/lab personnel exchanges

Note: The team all agreed to be involved in future activities.

US Industry 4: National Security and Criminal Justice

I. Team Members

Karen Clegg (Allied Signal)
John Decaire (National Center for Manufacturing Sciences)
Tom Garcia (LANL)
Virginia Green (Lawyer)
Richard Kegg (Cincinnati Milicron)
Bill Studeman (Military Consultant)

II. Team Composition and Preparedness

All players were very familiar with the handbook and challenges, but were confused on what the expected outcome should be: making deals/money or changing/redirecting the National Labs and changing policy.

The composition of the team was such that needed skills and expertise were available. For example the lawyer worked on policy change, the industry and military consultant team members worked on making deals by advancing technology, the National Labs affiliate worked on forming alliances that could posture their industry to take advantage of the labs expertise and policy changes.

III. Description of Planning Session

The planning session was very focused. After the establishment of ground rules, much time was spent to determine WHO the team was, WHAT their mission was, HOW and WHEN they would implement their strategies, and WHO was responsible for each assignment.

Challenges:

- What is our business?
- Finding partners to co-fund technologies
- Finding partners to support policy changes
- What is the role of Congress?
- What is the role of Control?

Mission:

- Maximize partnerships
- Enhance national security and public safety
- Maximize shareholder value
- Be premier manufacturer of defense products in a global marketplace
- A company focused on surveillance and detection

Strategies:

- Change national policy to foster cooperation between Industry and National Labs
- Identify technologies strategic to our business and invest in those technologies
- Identify important and breakthrough technologies our industry needs for the future; leverage their development while retaining some intellectual property rights.
- Leveraged funding to labs, universities and other industries to contribute to technology development of sensor technology for detection and surveillance.
- Form strategic alliances to include National Labs, Government, Suppliers & User industry.

Technologies and Toolkit options to focus on:
Tagging, encryption, mine detection, motion sensors, proximity sensors, material sensors, biosensors, data information processing, mobile power supplies. Long-term-semiconductors, expert systems.

Discussion about leading edge technologies that will impact the future. Industry folks responded that they are interested in short-term gain. You make your money selling the services and integrating all the technologies.

IV. Strategy Implementation

- New Toolkit options proposed to change policy (the team decided that policy options were more important than technology options)
- Invested in technologies to bring product to market.
- Structured partnerships with labs, universities for the funding of efforts.
- Leveraged funding to labs, universities and other industries

V. Level of Strategic Planning

Focus of the play was very creative:

- created new Toolkit policy options
- tried to buy CA National Lab (LLNL)

VI. Team Dynamics

Each team member faithfully played his/her real life role, i.e. industry wanted to make money, the labs people wanted more partnering and less DOE control, the lawyer wanted to work with Congress, etc. The interesting thing is that they all kept the team goals in mind and played for the betterment of the team, advancement of their industry, and change in the national agenda for R&D needs, and preserving the National Labs as a national asset.

Initially, decisions were made by thumbs up or thumbs down or neutral (majority rules). By later sessions, team members acted more autonomously. Votes on decisions were not taken unless someone specifically asked for a vote.

VII. Team Successes and Failures

Successes

- Network development
- All technology initiatives succeeded
- Leveraged funding for technology development
- All technology initiatives the team supported were germane to their industry
- Policy initiative passed (resulted in 15% tax credit even though Congress repealed the policy options)
- Most investments were leading edge
- Formed alliances on all initiatives (DOE, Labs, OFA were most strategic)
- Team members were still friends at end

Failures

- Toolkit policy options (P45 & P46) were repealed
- LLNL purchase was blocked
- Challenge Grant with DOE National Labs Security was poorly implemented
- Ground rules were not consistently followed

Observations

- Pursuit of policy changes were not rewarded.
- Breakthroughs in partnering were stifled by Congress.
- Policy options must be valued so that Industry/Labs will see how policy changes will affect the future
- Some players were handicapped by playing their real-life roles too realistically, that is they played Carpe Diem - make money today
- The team did not walk away feeling DOE/Labs learned anything from the game because no changes in policy or paradigms occurred, therefore there was no opportunity to explore usefulness or success/failure of policy changes or paradigm shifts.
- Team members were very irritated by Congress because they were too autonomous and were not influenced by a constituency - because they had no ties back to any team. They pushed their own agenda and many times their own personal agenda. Also, Congress did not change allocations.

VIII. Suggested Follow-on Activities

Department of Energy

I. Team Members

Vic Berniklau, Multitek, ABQ, NM
Jim Reafsnyder, DOE, Oak Ridge, TN
Robert San Martin, DOE, Washington, DC
Phil Stone, DOE, Washington, DC (didn't attend last day)
Jim Szenasi, DOE, ABQ, NM
Jim Van Fleet, DOE, Washington, DC

II. Team Composition and Preparedness

It appeared that everybody had received the Handbook and had at least skimmed it. It was not evident that everybody understood what the challenges were or why they were selected to play. (Not everybody was completely familiar with the purpose of the game.)

We did have two players who had participated in prototypes, so they assisted in the explanation of the game, but didn't try to persuade other team members into "doing this since we did it at the last game." They also didn't appear to alter how they played the game even though they had more insight than the others.

Everybody on the team works or has worked for DOE, so the expertise they brought to the game was a plus for this team. They all had or held positions at DOE that were appropriate for the play of this game; they were at high enough levels that they knew and understood the policies as well as the politics of DOE.

III. Description of Planning Session

The planning session went well. The team enjoyed the challenge and got out of the " box" discussing the future state of the world and how DOE could impact it. Their main theme was National Security; the public would support them in maintaining this mission once the public knew who DOE was and what they did.

The Challenges and Objectives were reviewed and discussed. Little action occurred in this area, especially after the first two challenges (strategic plan and 10-20 year changes) were discussed.

After much discussion about having pizzazz, being innovative, and being bold, the team was ready to develop a new mission statement for DOE based on their insights and enthusiasm. After lengthy discussions on the mission areas, the team soon discovered that the new path they charted for DOE was almost identical to the path it currently had (i.e., reverted back to being inside the box). It was "enlightening" for the team to realize that the mission and focus they came up with for their "ideal" DOE is the same as it is today. The mission areas chosen were National Security, Energy, and Environment, with an underlying foundation of Science and Technology feeding all three areas. Partnerships were also identified to be crucial to the future.

STRATEGIES

Once the team had all the assumptions and mission areas charted, they were ready to strategize. They distributed their strategies, mission areas, and planning assumptions to all the other teams (including their labs) assuming that everybody was interested in what DOE was doing, had planned, and intended to see implemented. (DOE did not pay much attention to the Goals distributed to them from the OFA team.) The DOE strategies are as follows:

National Security:

- Maintain core competencies at a minimal necessary level at weapons labs
- Insurance policy (market)
- Stockpile stewardship
- Increased emphasis on non-proliferation
- DoD is non-nuclear weapons lead!
- NS belongs to National Labs

Discussion: Much as before. Emphasis will be on non-proliferation and stockpile stewardship. Will have to market what we do in this area so the public will support our existence.

Energy:

- Sustainability (economic/environment)
- Insurance policy (market)
- Pollution prevention
- Portfolio of new and additional alternatives
    - Clean
    - Balance and mix of all alternatives
    - Not incremental
- R&D core/not large demos
- Industry/labs/university partnerships

Discussion: The core of energy work has to be R&D. Need to get away from the gigantic expense of repetitive demonstrations. Address needs through a portfolio of new and alternative energy sources. Generic R&D needs to be the core of our effort. Partnerships become more and more important in this area. Will have to start at basic side in order to be successful later on; may be 95 % lab to start, but will favor the labs for continued partnership growth.

Environmental Remediation:

- Must live with it in terms of nuclear cleanup
- Labs develop new technologies for cleanup, stabilization, isolation
- Labs don't do cleanup!
- Partnerships!

Discussion: Must live with it in terms of nuclear cleanup. Need to enhance and develop new technologies for clean up. The labs could partner with OFA in this area -- partnerships are the key. DO NOT want the labs to do the clean up; they develop the technologies. Pollution prevention is part of sustainability, but also applies to energy. If we try to get rid of environmental remediation, it will tarnish us more. Pertaining to nuclear cleanup, it is our responsibility and it couldn't go anywhere else (nobody else could do it). "It is our responsibility to pay for the sins of our fathers -- you make it, you clean it up."

Science and Technology:

- Supportive of National Security, Energy, and Environment
- Foundation for sustainability and competitive advantage
- Support of fundamental long term science (seed money)
- Lab/university/industry partnerships (in that order)

IV. Strategy Implementation

The DOE Team distributed their Strategies and Tactical Plans to all the other teams. They did not realize that the other teams, including "their" labs did not even read or consider DOE's Strategies when they made decisions for their teams. In general, the DOE Team was reactive, waiting for other teams to come to them, rather than proactive in pressing their strategies.

V. Level of Strategic Planning

In the early strategic planning, the DOE team was well outside the box. They were confident in the future of DOE because of their strong mission and what they provided to the public, especially in their mission areas (national security, energy and environment, and science) but also in other areas (collaborative work with others). They did realize, however, that the public probably did not understand the value of what DOE was doing for them and their future.

DOE also took great pride in what "their" labs were doing and what they contribute to the public (through DOE).

In subsequent rounds, the DOE team seemed to lose sight of their strategic plans and not until round 5 did they actually attempt to implement these plans.

VI. Team Dynamics

The team worked well together and brought their past experiences and their areas of expertise with them. A few of them had trouble in the beginning by trying to “sell” the importance of their areas over the importance of someone else’s area. After a few lengthy “soapbox” speeches, the team assigned that person to be responsible for all interactions in that area and moved on to the next project at hand.

The ground rules and role assignments were very basic. They divided up the responsibilities for interactions with the other teams based on their personal background. They had authority to make decisions with their responsible party as long as it did not involve funding and it supported the DOE mission. If funding was required, it would be brought back to the group for discussion and consensus for it to be formalized. The group agreed to meet every 15 minutes to make funding decisions and agreed that if only two people were present, they could make the decision. It all sounded good, but with the chaos of the game it rarely happened.

Although the team decided that it would only fund projects in their mission areas (especially late in the game), it was not easy assigning signed agreements into one of the four mission areas. However, it always was rationalized why the agreement was made and always did fit into one of the areas!

Team members tended to concentrate their efforts on those areas that they currently work in, rather than taking a more broad brush, strategic approach. In this respect, there were 3 DOE sub-teams representing energy, DP, and field offices.

VII. Team Successes and Failures

The team was successful in getting out of the box in the beginning and at the very end (Session 5). They did a good job of strategically planning including tactical planning, but the follow-through fell short. They were also successful at making timely decisions in the beginning, but fell short in the end. They were successful in gaining a new found respect from the labs late in the game (by tightly controlling the Labs budget). They also took pride in the successes of the labs, even though the labs didn’t consider DOE part of their success.

The biggest team failure was reverting back to their comfort zone in the box. They had great ideas in the beginning, but did not follow through. They did not really deal with some of the challenges they were given, such as privatization of the labs (they really did not force any issues). They also did not communicate well with the labs as to what they wanted and what they expected. They also focused on little project initiatives, not broad policy decisions. By spending small money everywhere, they didn’t have big money to spend in important areas.

VIII. Suggested Follow-on Activities

Suggested follow-on activities were very broad high-level ideas (more policy involvement, more inter- and intra-government involvement, better communication, etc.). Although everybody agreed on what needed to happen, it was not evident that anything would really change when the team returned to the real world.

Other Federal Agencies

I. Team Members

Dr. Ruth David, Deputy Director of Science & Technology, CIA
Frank J. Gaffney Jr., Director, Center for Security Policy
Kent H. Hughes, Associate Deputy Director, DOC
Michael P. McRaney (Gen-Ret.), President, McRaney Associates
John Pinkston, Chief, Office of Research, NSA
Dr. David K. Sharma, Administrator, Research & Special Programs, DOT
James A. Williams, (LtGen-Ret), President, Direct Information Access Corp.

II. Team Composition and Preparedness

The OFA Team was truly a team. They all had different backgrounds and represented different entities, but they made the effort to understand each other and to focus on the objectives of the game. All players were very capable of representing their constituency. A significant gap in the team was the lack of anyone from DOD with weapons experience.

It appeared that everyone had reviewed (but probably not studied) the handbook. Some players were more familiar with the Toolkit options than others. With the guidance of the facilitator, they quickly grasped the concept of the game and they played it to the end.

III. Description of Planning Session

The OFA team decided they would represent all agencies which are involved in R&D. They decided not to have each member represent an individual agency but rather the **OFA Team was one group representing various agencies.** Their rules of conduct were simple. Anyone could call for a vote; there would be limited debate and then a vote (majority rules). The emphasis was to be on speed and flexibility. They discovered early that each showed consideration for the others and that they could disagree without resentment so complex rules of conduct weren't needed.

No role assignments were made during their initial planning. After the Toolkit session they realized they needed a coordinator. Jim Williams was selected and did an excellent job of coordinating, keeping the team focused, and provided the common point of reference on approving deals. Team members evolved into roles reflecting their backgrounds and interest. Frank championed defense, Dave worked on physical infrastructure, Kent and John looked at education and environmental issues, Ruth concentrated on computing and information, Mike and Jim worked on issues across the board, and all members tracked and supported each other's activities.

The team followed the facilitator's lead and actively worked on developing visions for national security, quality of life, and economic security. Priorities were established, strategies were laid out and metrics set.

Vision

National Security

- World-wide R&D lead in specific core competency areas
  - Secure communications
  - Microelectronics and optoelectronics
  - Nanoelectronics
  - High performance computing
  - Biomedical
  - Energy management
  - High energy physics
  - Advanced materials
  - Environmental cleanup
  - Aerospace
  - Transportation technology
- Provide secure social environment
- Establish a stable society amenable to long term planning
- Improve quality of life for our citizens
- Maintain US as leading world power
- Emphasize strength inherent in people
- Recognize the multi-national economic environment

Quality of Life

- Environmental cleanup and sustainability
- Medical breakthroughs (AIDS, bio-engineering, cancer, economical health service)
- Physical infrastructure
- Secure information infrastructure
- Assured personal physical security
- Ability to cope with natural disasters, terrorism, etc. (dual use)
- Enhanced program to fight drugs
- Improved racial harmony
- Increased understanding of other cultures

Economic Security

- Sustainable energy supply
- Increased employment portability
- Healthy manufacturing infrastructure
- Leadership in information infrastructure
- Hard core competencies (agriculture, bio-medicine)

Priorities

- Secure, robust and widely applied information infrastructure
- Deterrence & defense of non classical attacks
- Sustain & improve environment
- Education/enhanced employability
- Global projection of American power & influence

Strategies

- Use labs, industry, universities, (and foreign where appropriate) to meet vision
- Long-term focus (industry covers short term)
- High risk, high cost R&D (initial investment)
- Have a viable US manufacturing base
- Push Congress for multi-year funding commitments
- Standards and interoperability for information infrastructure (security aspects) and others as appropriate
- Invest in security technologies
- Stimulate consortia development in areas needed (Sematech model)
- Build coherent multi-year program for design & development on non-classical defense
- Exploit information technology in support of continuous learning
- Stimulate new industries based on core competencies

Metrics

- GDP/capita increase (rate increase to 2% by 2005)
- Profitability of leisure industry (Measure of good jobs and leisure time available)

- Trade balance (consider our share of world exports)
- Defense preparedness (measure quality, not quantity - focus on capability of precision strikes)
- U.S. influence in the world

IV. Strategy Implementation

With well thought-out strategies and priorities the team knew what they wanted to achieve. They took a systems approach, not unrelated discrete actions. They continually monitored their progress with respect to their priorities.

The team got off to a slow start in the Toolkit session and primarily worked within the team. They invested in T5 (virtual work environments) and T33 (anti crime and terrorism), but were unsuccessful in T4 (security for information and communications). They went into Session 3 more aggressively (they interacted with other teams much more), with initiatives going forward on three parallel fronts. They marched to the priorities they had developed, not directly addressing the challenges in the Player's Handbook (although most were covered by their actions). They led efforts on information security, anti-terrorism, and design of a new weapons system.

They recognized and used their leverage as a funding source for industry and Universities to gain cooperation in their areas of interest (accused by Industry of extortion). In reply to proposals they liked but did not feel OFA should support financially, they encouraged the effort and promised rewards such as a ceremony in the "Rose Garden" (e.g., smart modem for education - OFA said Industry should fund since they would reap high profits).

They were shocked to find little support from DOE, National Security Laboratories and Industry on defense projects.

V. Level of Strategic Planning

The OFA Team began play at Level II, based on their extensive and deliberate planning. They knew what they wanted to accomplish but initially were unsure of the game and how to proceed. They had little success in gaining support from others for their Toolkit interests and were forced to react at the last minute. After that, they rapidly developed their partnering skills and learned how to use their OFA role to influence Congress and Industry. Their time horizons were usually 5-10 years with occasional looks beyond 10 years as the game progressed. They were often at Level III in the later stages of the game. They observed and played off what others did, creating and investing where it added value to their goals (e.g., Mike developed a public relations strategy for both DOE Lab groups in which OFA and the labs committed and invested). Their play was creative, especially in the defense area where they had no DOD weapons experience to guide them.

VI. Team Dynamics

The OFA members bonded as a team early in the game despite great diversity in personalities, knowledge base, and operating styles. The well-facilitated planning process helped them get to know each other and find common viewpoints. When they found that they could disagree and reach accommodation, the level of trust went up again. A reoccurring point of discussion was the balance between a global economy and national interests. Efforts to reach consensus or even a vote by all the members proved cumbersome in Session 2. After selecting Jim Williams as coordinator, they grew confident in his ability to ensure that they were on track with team objectives. This allowed them to work individually or in small teams to develop deals more quickly and to involve more partners. They really embraced the power of partnerships when they saw how little they could accomplish alone and what was possible through cooperation. Mike acted for Jim during his absence on Wednesday.

VII. Team Successes and Failures

Successes

- Investments and successes in all priority areas
- Communication security addressed
- Shifted some focus to national defense
- Increase in defense preparedness
- Increase in quality of life
- Economic Security initiatives
- Lab marketing initiatives

Failures

- Multi-year funding not achieved in Congress
- Game did not reflect complexity and impact of Intellectual Property
- Congress was not convinced of value of Labs

VIII. Suggested Follow-on Activities

- Marketing for Labs - Mike McRaney
- All players will work on achieving multi-year funding (e.g., through Congressional testimony
- Bi-directional staff rotations (NSL/CIA/DIA) - Ruth David
- Smart modem project for education - Kent Hughes
- Everyone involved in R&D must be able and willing to articulate it's importance
- There is a real strength in interagency cooperation and we need to continue it - Dave Sharma

Universities

I. Team Members

Dennis Barnes, President, Southeast Univerities Research Association
Mark Brodsky, President American Institute of Physics
Paul Huray, Distinguished Professor of Engineering, University of South Carolina
Darrell Morgesen, Manager, Los Alamos National Laboratory
Roger N. Nagel, Executive Director, Iacocca Institute
Barbara F. Perry, Director of University of California Office of Federal Government Relations
Carl H. Poppe, University of California Vice Provost Research & Laboratory Programs

II. Team Composition and Preparedness

It was abundantly clear that each member of the team was highly skilled and represented a wide range of university constituents. Dennis, Barbara, and Carl seemed to relate best to university administration, funding problems of universities and the "big picture" of universities. Paul seemed to relate to universities at both the administration and teaching levels. Roger was more focused on what the university might become in the future than their day-to-day problems. Darrell works for LANL, an institution operated by a university; therefore, he related more to federal laboratories than universities. Mark is a former IBM executive that now represents a professional society. He related well to companies, but did not seem sympathetic to the problems of universities or federal labs.

All of the members felt that they had made a major investment in studying the games book. One team member remarked that he had spent an additional two hours doing a second review. Yet, during the game, it was sometimes unclear to the players what was coming next and what constraints were faced by the team. Darrell, a previous player with a strong understanding of game dynamics, and the facilitator were able to clear-up uncertainty and help players avoid de facto decision making. Nevertheless, the fact that uncertainty existed suggests that coherent strategy development could have been inhibited. Perhaps a roadmap front cover that outlined the flow of the game and highlighted the rules of play would have expedited play.

III. Description of Planning Session

There was uncertainty about whether the team was there to promote federal labs or to look-out for universities' interests. It was decided that actions taken by the team should be in the best interests of universities. Barbara, Paul, and Carl were keenly aware of the declining budget problems faced by universities and attributed these to be due to (1) reduced DoD R&D budget and (2) the inability, due to HMO pressures, to use university hospitals as a "cash-cow" to fund university research. Roger urged the group to accept that the financial problems of universities would not be solved by public funding; alternative funding sources from the private sector would be required in the future. It was remarked that university faculty have an entitlement perspective and do not understand that education is undergoing massive change. For example, the average age of a university student has increased 6 years during the past decade. The group determined that it would have the mindset of a research university and that all of its actions and deals would be consistent with and build on the university values of teaching/learning, research, and service to the community and nation. Roger demonstrated a strong customer focus and urged the group to think more about what the US needs over the next 20 years and to identify how universities can help provide for these needs. Darrell also encouraged and demonstrated long-range strategic thinking.

In arriving at the above mindset several goals, objectives, stategies, observations and problems were discussed including:

- Reconfigure both federal labs and universities to maximize public good.
- Create and develop a national education network.
- University costs are out of control and the cost growth rate of education is even higher than that of health care.
- Universities have a trusted third party image.
- Reestablish the principle with the Congress that the primary role of government is to support basic research and basic research is best done at a university. One member expressed fear that the national labs want to get into the basic research and teaching business.
- Revive university-industry partnerships for real world experience.
- Industry associations should promote university research (like SRC does for semiconductors) and seek joint funding by government.
- National university organizations that facilitate the funding of university research by industry should be established.
- DOE should create large facilities for university research in "big science" projects.
- Universities should co-develop with national labs a national education delivery system and work with them to conduct pilot projects, e.g., information technology.
- In w years universities will perform x percent of US basic research with y percent funded by industry and z

percent funded by government. (*w*, *x*, *y*, and *z* were never given specific values.)

- Universities should use their skills to increase US economic strength, improve public health and wealth, and provide knowledge-based world leadership.
- Joint professorships - research appointments with both federal labs and industry are needed in order for universities to maintain and improve the world class educational environment for students of all ages.
- Universities must develop a broad constituency base that will speak-out on their behalf.
- Universities should use the technology of virtual organizations to revolutionize how education works and how technology is shared.
- The US education system must anticipate US 21st century needs and begin preparing for these needs.

Throughout the discussions Roger consistently urged the group to think strategically, not tactically, and admonished the group to focus on reinventing universities to be national assets 20 years into the future. He came across as a customer-focused visionary that is genuinely interested in making universities better serve mankind. He argued that universities must provide flexible education in a way analogous to agile manufacturing systems. Members of the group that were closest to universities pointed out that universities do not want either government, industry or federal labs to specify their research agenda.

Some members of the group seemed inexperienced in strategic planning and appeared to be more comfortable with tactical thinking. Evidence of this was the difficulty they had sorting out goals, strategy, and metrics. Nevertheless, throughout the game, the team, with the urging of the facilitator, frequently revisited their values to see if their actions and values were consistent. Furthermore, the group excelled at the tactics of play and making win-win deals with other teams.

The notion that growth in federal entitlement accounts would eventually drain federal investment in R&D occasionally surfaced and was commonly acknowledged as being a major problem, even a show-stopper, but these discussions failed to take roots and did not lead to team action. One member noted that the political risks to universities for addressing the entitlement issue were overwhelming and should be avoided.

The group reviewed the experiences of each member and identified its members that were most familiar with other groups in the room. In a typical university way of selecting leaders, Carl was selected to chair the group, not so much as an honor, but more as odd man out - other members were needed for more specific work. The chairman asked each member to select 5 Toolkit options for investment. This was done and a priority list of Toolkit options was selected by consensus. At this point in the game there was a shift in team leadership from the facilitator to the group chair.

IV. Strategy Implementation

At first, some members of the group attempted to implement their personal agenda; others pursued the group agenda for Toolkit options. Several team members went to other teams to discuss ideas as well as policy and technology options. One player helped the chair identify preferred Toolkit options and fall back positions in case the preferred Toolkit options (T5, T6) did not materialize, and interacted with other teams that approached the Universities.

The team rejected partnering opportunities that did not show immediate benefit for universities. At the end of the Toolkit investments the team was pleased that all of its investments supported its vision for universities, that all investments had been successful, and that its top priority Toolkit options had been supported. The facilitator helped the team develop this mindset. There was almost a feeling that the team had accomplished its goals to such an extent that, except for improving K-12 education, there was little left to do in the remainder of the game.

At this point the chair split the group in two teams: one to pursue K-12 and the other to work on a major health care initiative. As the discussion of health care issues progressed, most of the team members resonated with the idea that this was a “grand challenge” area that universities could lead rather than respond to government or industrial leadership. The idea quickly evolved to the point where universities would use federal labs mapping of the human genome to do basic research that would lead to elimination of all diseases and make major reductions in health care costs. The chairman spent the better part of an hour crafting a proposal to take to the control team. The proposal was rejected because it promised too much for the R&D investment. At this point there was concern that the control team’s decision might dampen the enthusiasm the group had for this idea. Instead, rejection served to hone their interest. During the process of rewriting the proposal, one member of the team was not engaged in the “grand challenge”. He was very concerned that the team would “put all of its eggs in this basket” and have nothing to show for its efforts if it failed. So he independently crafted a proposal for a global village and found support for his idea around the room.

At the end of the day the team helped the chair prepare his presentation for the next morning summit and resolved to push their human genome “grand challenge” through the next day. They knew it would be difficult because it was evaluated as a $500 million project by the control team.

After the summit, the group really came together with a single-minded objective - get their "grand challenge" funded. For the remainder of the day members of the team scurried about the room making deals to support other projects only if those projects provided even more support for their "grand challenge." They carried over their money into the last session and increasingly gained support for their project. When the control team "rolled-the-die," every member of the team was standing around the control team and they celebrated when they won the "roll."

V. Level of Strategic Planning

Early in the game most of the members were in a tactical mode while two were in a strategic mode. However, as the game progressed, the entire team became more strategic and began to see the need for a "grand challenge" to help universities focus their energy on an important international problem that the American public really wants solved and that universities could lead. The team talked about where national labs would take genome mapping by 2010, predicted how the public might react to knowledge that their newborn children would be stricken with a fatal disease, speculated that this public awareness would stimulate the political system to increase funding for elimination of genetically inheritable diseases, and determined that these events would create new research opportunities for universities. They consistently pursued activities that were consistent with their vision of universities as resources for teaching, learning, research, and service to the community and nation. Nevertheless, while maintaining this long-range focus, the team was easily able to respond to game tactics and rally support for their "grand challenge."

While the importance of partnering between universities and partnering between universities and companies became increasing visible to the team, partnerships between universities and federal labs were only given lip service. That is, they were endorsed philosophically, but in practice, federal lab partnerships were ignored. Their behavior suggested that they regarded federal laboratories as irrelevant to the future of universities. Some members of the team felt that federal laboratories tend to be large central facilities that are not widely linked to companies around the country. This led to the recommendation that universities become the distribution system for labs technology and help get their technology into the hands of companies where it can be applied.

VI. Team Dynamics

The longer the game progressed, the higher the level of unity that evolved among its members. By the final day they had really become a team in which each member was empowered to make deals on their own without group approval because it was clear that each member of the team had the same objective in mind - get the "grand challenge" approved. Members of the team were moving faster than their chair was able to track, but everyone in the group was comfortable with this behavior.

VII. Team Successes and Failures

Everyone in the group was empowered. This led to creative, entrepreneurial behavior because everyone in the group knew what the team wanted to accomplish and it stimulated each member to take the game seriously. Interaction with other groups led to relationships that some members thought would be retained. The general feeling was that all of the other teams were real in their behavior and represented their constituency well.

Members of the group were grateful that Congress didn't offer very much help; consequently, the practice of "going to the trough" of public funding was abandoned. Most felt this behavior to be needed in the future. The experience of "horse trading" with industry was a new experience that felt good and seemed representative of the future of universities. The team quickly learned that they could negotiate with other teams and win the support of other teams only by identifying how their partner would benefit from the partnership. Even though none of the team members was a biologist, they had a strong collective sense that their "grand challenge" was a winner and that the public, therefore, Congress, could easily relate to their "grand challenge." Most thought that it was the "grand challenge" that made the game fun and allowed team members to experience the most learning.

The team experienced feeling powerful and highly successful and attributed that to universities working collectively as a single community to solve an important national problem. They liked taking a big risk and winning! The team learned that opportunistic behavior can work in the common interests of universities. They also learned to listen to what other teams wanted and to arrive at partnerships that were mutually beneficial. They found the experience of focusing on a single goal to be a significant learning step. They determined that it was easy to make decisions when each member of the group knew where the group wanted to go. They found the overall experience demonstrated the importance of trust within teams and reinforced their belief in the importance of persistent pursuit of goals.

The group felt that the experience of this game demonstrated to them that the nation needs a way to establish, grow and nourish new initiatives as “grand challenges,” test their success as they evolve and have the flexibility to make mid-course corrections as needed. They were also pleased to see national leadership coming from entities other than government.

While the team really never developed a strategic plan, it was felt that the clarity of vision led to a coherent strategy.

This team observed that the Federal lab teams were often stuck waiting on DOE to tell them what to do or approve a lab request. One member remarked that the labs don’t know who they are, what they want to be, or what they will be permitted to become. Another remarked that they just seem to sit and look helpless while DOE jerks them around. Unlike the labs, the university team felt like it quickly came to understand who it was and what it wanted to accomplish and that was an important reason for its success. Another observed that it was beneficial to see that other groups also regarded the labs to be irrelevant.

VIII. Suggested Follow-on Activities

It was recommended that new national policies are needed that facilitate joint appointments between universities, government labs, and companies and that universities need to establish organizations that develop partnerships.

DOE National Security Labs

I. Team Members

Alan Bennett, LLNL
Dale Clements, Allied Signal
Spiros Dimolitsas, LLNL
Dan Hartley, SNL
Peter Lyons, LANL
Paul Robinson, SNL
Warren Siemens, SNL

II. Team Composition and Preparedness

The composition of the team was excellent. There was a broad base of expertise and knowledge among the team. About half of the team players were eager to go out and make deals; we had to push the other half, or at least give some guidance. Most of the players were familiar with the handbook, at least at a high level, and some really understood it. The challenges were never discussed, despite several ‘prods’, but I think the players felt the challenges in the handbook were reasonable and did not have to be addressed. Two of the players had played in the prototype; each displayed no preconceived notions from the previous experience and felt there was a great deal of improvement in the actual game compared to the prototype. Each player brought in his own expertise to the game, which resulted in a unified effort by the team to succeed.

III. Description of Planning Session

The team used the time during dinner of the first evening to discuss, generally, where the labs should move in the future. It was decided that the three labs would work as an integrated system to maintain their multi-disciplinary response capabilities. The team started the morning planning session by designing and passing out a questionnaire to the other teams to solicit knowledge as to what the other teams wanted from them.

Goals were then prioritized and fleshed out as follows:

1. Mission
   - Labs are multipurpose
   - Maintain national security (broad definition) focus
   - Capture benefits for US taxpayers
   - Develop/maintain freedom to support wider base of government agencies (be true “National Labs”)
   - Maintain defense readiness (separate mission)
   - Be critical to future of US

2. How we operate (approach)
   - Treat 3 labs as an integrated system
   - Do government work using private sector methods
   - Develop constituency of champions (Wheaties)
   - Maintain multidisciplinary response capability
   - R-D-A (research - development - application)
   - Build partnerships with industry and universities
   - Be research provider and user
   - Define desired relationships to other DOE/ DoD labs
   - Improve cost effectiveness

3. Crosscut
   - Recreate/re-engineer new R&D system for the United States
   - Widen range of contributions from US investments in science and technology (As a supplier or partner)
   - Create win-win incentive for partnerships (lab-lab, lab-industry, lab-university

Strategies and actions were defined to reach these goals. The team chose not to work with the foreign team due to security concerns and image of a national defense lab working in any area with foreigners. There was little interest in ground rules. The other rules were developed ad hoc; i.e., as it became obvious the whole team could not visit every table—they self-selected to interact with specific groups; as it became obvious that a visitor that wanted to talk to our whole table was disruptive—they chose to have the WL team delegate to the visitors group talk to the visitor off-line. Toolkit options were prioritized. A lot of emphasis was placed on what other teams wanted partly because we had limited resources.

IV. Strategy Implementation

Objectives were restated after Toolkit successes and failures were defined. ASCI was a big deal to us, we put most of our Toolkit money into it, and it failed. Thus we organized a computing summit to build support for a National ASCI (beyond DOE/DP) or NASCI program. Support was generated, money collected, and the proposal succeeded. We also worked with industry on the E&E summit and on a counter-terrorism initiative, and on enhanced surveillance. These were good efforts; the group, with little money, teamed to get these proposals rolling. The team referred to the prioritization we had done for Toolkit options and let that list drive them in later sessions. They wanted to be collaborative, and the moves were long term—there was almost no interest in money, ROI, or whatever, except that money allowed them to do the things they wanted.

The team had some very good moves in the beginning of the game, especially the marketing survey, (although they failed to follow-up on it and this could have helped them throughout the game.) I think it would have improved collaborations and possibly it could have pushed them to be more competitive. They didn't seem to be too concerned about how they were playing the game until Control told them to be more assertive.

V. Level of Strategic Planning

The team looked to build on previous things, NASCI on top of communications to improve education, etc. But there was no contingency planning such as "we'll start 2 or 3 things" (but they didn't have money or time to do this). If forced to select a number, I would rate their planning and execution between levels 2 and 3, the agreements taken together succeeded, but also there was a series of contracts and Toolkit options—i.e. the communications, then NASCI, then education based on computing and communication.

VI. Team Dynamics

Although others viewed this team as staying at home too much, I felt that they were proactive in getting questionnaires out to all other teams immediately Tuesday morning and setting up meetings with other teams—first, although some, like Congress, would not even talk to us. Some also were aggressive in seeking deals; Dan in the environmental area, Pete with Congress and with Industry 1&4 to build an enhanced surveillance consortia (it eventually failed due to industry squabbles), Paul in the computing area, and Dale keeping DOE happy. Some on the team were less aggressive but would go out if opportunities were suggested to them. There was not really a "stay at home" organizer; Paula and I kept tabs for them on what others were doing, Paul was clearly the person they checked with to see if their deals were OK. There were few vetoes, except on foreign involvement; if someone in the group wanted to deal in general agreement with their objectives, and if there was money, they made the deal.

VII. Team Successes and Failures

NASCI was a big success, "Fraunhofer-like" institutes were approved, E&E initiatives passed, education based on computing and communication passed, labs stayed intact—in part due to issue-oriented Congressional testimony.

Enhanced surveillance for weapons and reactors failed, DOE—when given the chance—reverted to their old selves and stopped all actions in session 5, until 10 minutes before it was over. Then, DOE said at the end, that they finally got their act together in session 5 and were successfully involved—our team was very discouraged by this perspective.

My biggest problem with the game was the result: "the labs are irrelevant to industry and the universities." With DOE in power we are prevented from doing things that might make us relevant, and DoD does not think we are tending to national security.

VIII. Suggested Follow-on Activities

Spiros wants to work on MEMS (micro electro mechanical systems). Paul should keep talking to Congress as successfully as he did here. Also interested in continuing: NASCI, Fraunhofer-like institutes, P-45 & P-46, DOE policy changes, and N-35 Industrial technical information network (virtual customer alignment).

DOE Civilian Science and Technology Laboratories

I. Team Members

Harvey Drucker, ANL
Charlie Gay, NREL
Bill Guyton, INEL
Beverly Hartline, CEBAF
Bill Madia, PNNL (5/6-7 only)
Bill Martin, ORNL
Charles Shank, LBNL (5/6-7 only)
Al Trivelpiece, ORNL (5/6-7 only)

II. Team Composition and Preparedness

This team came familiar with the handbook and prepared to play. They were well matched for their roles since all team members were either Directors of DOE Civilian S&T labs or senior lab personnel involved in high-level issues. The team was not impressed with Toolkit items as listed in the game manual and seemed ready from the start to write several new options that were of interest to them individually or collectively.

III. Description of Planning Session

The team took exception to being named "Other," saying it was like not being considered on a par with the Weapons labs. Consequently, one of their first acts was to change the team name to DOE Civilian S&T Labs.

The first step for the team was to discuss their current situation. They asked themselves what did they have in common. Their answers were (1) a vested interest in education and (2) a strong investment in technology. They felt the country needed a robust science based energy policy and that gas prices going up is a good sign validating this position. DOE taxes are a problem and so are the DOE requirements of having WFO customers pay first and potentially having to apply NEPA on a project-by-project basis. In general, the labs cost too much and need to do things collectively. The long-term protection of the labs as a national resource best comes by being an institution or "system of labs."

The team discussed several specific game questions such as: How does money work? What is the minimum investment? How will we decide on ground rules? Answers were provided to the best of the facilitator and analyst's ability.

The team next worked on defining their objectives, mode of operation, and strategies (although not always sequentially in this order). The team never seemed interested in the challenges listed in the game manual and never spent any time discussing them.

Objectives

The following objectives were established by the team:

1. Provide for a secure energy future
   - fission, fusion, fossil, conservation - closed, complete nuclear fuel cycle - reprocessing/breeder economy - Uranium will burn out in 42 years
   - energy efficiency implies higher temperatures which implies materials problems
2. Provide science and technology (S&T) infrastructure
   - basic, high risk, large scale, energy and environment (E&E)
   - country needs an infrastructure
3. Provide environmental surety/stewardship
   - zero manufacturing emissions, zero discharge emissions
     - clean water
     - NOT suck, muck, and truck
     - consider carbon fuel emissions
     - may need tax credits/policy/law changes

Strategy

The team developed a general game operational strategy fairly quickly, albeit informally. There was no natural trend toward formal strategic planning processes. The consensus game strategy is as follows:

1. Identify targets of opportunity [other teams such as Industry (E&E and Manufacturing), Foreign, DOE, Universities, Congress, etc.]
2. Find out what they want and see what matches the capabilities we have to offer (consistent with our long-term objectives)
3. Sell it to them

Ground Rules

The team discussed, but did not seem to converge, on any long list of game ground rules. The overall style was collegial. Decisions were to be made by majority rules with significant empowerment to whomever happened to be leading an activity at the moment. Individual assignments were made for team members to perform market research and to serve as prime points of contact with other teams.

There was no movement toward formal subteams nor any significant interest in establishing rules relative to appointments or interruptions by other groups. The analyst was selected to serve as banker and to handle the organizational records. No single team leader was selected in a group that was full of leaders.

Initial Tactics

In the planning session, the team agreed to pursue the following initial steps:

1. Eliminate 1) upfront payment by WFO customers, 2) the tax (added factor) that DOE collects, 3) project by project NEPA
2. Conduct market research on what targets customers want
3. Invest Toolkit dollars to enhance cost/operations competitiveness of the labs (e.g., a Toolkit option to eliminate DOE tax, etc.)
4. Get Congress to support R&D as a policy
5. Work with Universities to attempt to sell basic science
6. Establish partnerships around facilities in DOE civilian laboratories
7. Focus investments on maintaining vigorous basic S&T investment in DOE civilian labs
8. Invest in fission, fusion, renewables, clean fossil, and clean water

IV. Strategy Implementation

A significant fraction of the high-level direction for this team was established during the first evening session. This team did some of its best thinking at a high philosophical level but struggled to work as a team on detailed tactics. Consequently, the team pursued a number of actions at the start that could have been framed as either Toolkit items or game agreements. There was an attempt early in the morning of Tuesday to go and gather intelligence information on what other teams (customers/partners) might want from the DOE Civilian S&T Labs team. This information was shared among team members but was not used for defining specific initiatives at this time.

1. The group went through a period of unfocused activity where a number of initiatives were simultaneously pursued by individuals or subgroups. One accomplishment achieved during this period was a reduction in cost through negotiations with DOE. The requirements for a DOE added-factor tax and advanced payment by WFO customers could be waived. While this was one of the team objectives, it was never marketed during the balance of the game and never generated a specific return on investment. Only when it became obvious that concrete action had to be taken on the Toolkit, did the team focus on this activity.

In the end, one could have concluded that for this team the Toolkit negotiations turned into a popularity contest that was not too related to team objectives. The Civilian S&T Labs team was quite proud of the fact that they knew enough (in contrast to the Weapons Labs) to not invest in the industry new Toolkit option (P45) requiring a minimum percentage of R&D funds going to industry.

After the Toolkit options were submitted, the team became more focused on investment initiatives. They decided to start major initiatives on health, computers, energy and environment, and water. The health initiative was subsequently delegated to the University team. The computational initiative was started in cooperation with the DOE National Security Labs, but was eventually delegated to them. The team decided to have a meeting of parties interested in E&E issues.

2. This mini-summit was a disappointment for several team members because it showed Industry pulling out of support for large initiatives with government involvement (e.g., bad taste to "government" involvement/ control/ waste). Industry appeared only interested in their initiatives and how labs might contribute to their programs. In retrospect, while the team was unable to establish a large nationally coordinated initiative, many of the individual pieces of their strategy were eventually pushed to successful completion.

At the start of the second day, the team was informed that a number of the other teams (particularly industry teams) had questioned the relevance of the DOE laboratories. Regarding lab relevance, the team initially seemed to be in a state of denial. Some realism seemed to be "creeping in" related to Tuesday's experience where industry said that they didn't want to partner with "government". The team took the feedback as data and got to work. Wednesday morning was spent negotiating.

This game play was very hectic at the end because of the necessity to get funds from DOE while simultaneously negotiating deals. Several interesting ideas developed by the team during this last session related to brownfields, foreign partnerships, and having lab personnel serve as virtual detached "Kelly girls" with a physical infrastructure to support them. During the later wrap-up session, the team was able to map their investments into their strategic objectives.

V. Level of Strategic Planning

This team developed several strategic objectives but never concentrated on writing down the details to carry them out. The details were left to the student.

VI. Team Dynamics

This was a congenial group throughout the game. The members liked and respected each other. Many had worked together in the past and expected to work together in the future. Consequently, conflict was typically avoided. Four lab directors attended the Monday evening and Tuesday day session (Bill Madia left at 4 PM on Tuesday). Consequently, the team was "leader-full." No single leader arose to direct or coordinate actions. The group stated that it would split by customer/opportunity target. The challenge to the team staff was typical of herding cats.

The team was very incensed about what they believed was a fundamental bias in the game towards the weapons labs. They felt that there were numerous subtle snubs against the "Other labs." The initial team name was just one example of a perceived slight. The team did have a feeling of being treated like second-class citizens both in the game and potentially in real lab interactions. For example, they commented on the DP not sharing the DP budget but the ER/EM sites were sharing a large fraction of the ER/EM budget.

The small dollars to DOE/Labs made this team feel subtly irrelevant. However, the team did recognize its limited dollars and consequently always formed partnerships to leverage their limited dollars.

The team may not have bought in to the game as fully as they might have. Lack of realism and some game artifacts were very frustrating. The team was primarily interested/involved with philosophy and viewed S&T as a given and general good for the nation. The team was a very engaged bunch having lots of fun. The major issue was achieving focus in the game. The team struggled to be able to establish specific initiatives or investment options. They never really teamed with DOE.

The team remained at a high philosophical level and struggled to get down to more concrete tactics. The team successfully developed high-level objectives. However, the team had difficulty when the high-level agreements generated from these objectives were rejected by the control team as lacking specificity. This team felt they were at 50,000 feet while control team was viewed at -6 feet.

This team did not like the Toolkit options. They wanted to write their own but struggled with this option (frequently confusing Toolkit with other potential agreements). The team ignored the challenges in the game guide.

The team aggressively tried to organize "national integration" initiatives (e.g., national energy strategy). These global integration initiatives bogged down (e.g., specific industry objections) but some concrete pieces did flow from this effort. However, in general, the team play ed their role well but they did operate within their expected box. There were no unique innovations or specific entrepreneurial efforts that were brought forward in this game.

This team could have gone several directions at the start of Wednesday since three strong figures (3 lab directors) did not return for the day (they had a real-life Congressional hearing). There were several strong personalities left in the team and one question was certainly how they would interact. In the staff opinion the result was very good teamwork. The group was able to divide work well and simultaneously complete tasks in perhaps a greater spirit of fun than was present on the previous day. In the staff opinion, the team was more successful in the game on Wednesday than they were on Tuesday. This may have been the result of game learning since there was some feedback provided from the previous night's staff session. The team continued to challenge any game feature that they did not like.

VII. Team Successes and Failures

The team rated itself a 4 on their performance versus objectives. They felt that they had listened to what their customers wanted and invested in a manner consistent with their objectives. Their weak point was that they felt that they had done less well in pushing basic science and technology. Some of their notable accomplishments are as follows:

1. They had participated in nearly 50% of the investments made in the game
2. All of their Toolkit investments were successful
3. All of their investments were true to their objectives
4. They had initiated some major activities (e.g., mini-summit on E&E)
5. Each investment by the team had an average of four partners

A self-assessment of some of the team's successes and failures yielded the following:

1. Robustness of their strategies was good
2. Did a reasonable job listening to customers
3. Didn't sell long-term basic research as well as they wanted
4. All of their agreements had multiple partners
5. Successful on most investments
6. Flexible to DOE's changes
7. Team invested in <u>every</u> investment that did not pass (*ed. note - these were few in number*)
8. Notable team actions: started big initiatives, used matching strategy for funding, and team forced DOE to make decisions fast at the end
9. Last round was painful but they took more risks in making deals with industry, overcame constraints while DOE was justifying their existence through increased

controls, and Industry really had an impact on their deals in the last session
10. Kept DOE informed, spent all the money, partnered successfully, beat weapons labs

The team had the following observations that went beyond the specific game setting:
1. Future emphasis will be on computing, networking, and computer security
2. They met some new people that are valuable contacts for "real life" events
3. They improved the contacts with one another
4. Some concern over analyzing/self aggrandizement/ saying that they really made progress -- when they really didn't do anything, or learn anything that they didn't know before the meeting
5. Made some obstacles more clear and identified some corrective paths
6. In the future, DOE labs will have to do a lot more partnering -- learned that ability to coordinate partnerships requires aid and few barriers from DOE
7. R&D tax credits need attention

VIII. Suggested Follow-on Activities

The team brainstormed the following follow-on actions:
1. Why don't we form a civilian S&T system? -- gang together
2. Sign-up to coordination/communication
3. Telephone video conference 30 min each month to be organized by ORNL exchange ideas -- for 6 months
4. Go to each other's community to talk to various constituents (show that we are not just "regional labs")
5. Work together to develop support for fundamental research? Ask why did SCSC fail (do a real objective postmortem)
6. Establish a real national spokesperson for S&T
7. End carping (results in fratricide)
8. We need a "mother (advisory) board" or maybe a total DOE not just the parochial pieces

Further discussion led to these specific steps to emphasize a DOE system of labs:
1. Mini-virtual office of principals with a monthly videoconference organized by Bill Martin, ORNL
2. Exchanges to reduce perception of regionalized labs. Specifically, Harvey Drucker would invite INEL representatives to the American Welding Society in Chicago and NREL representative to an Illinois Farm Bureau meeting

Foreign Countries

I. Team Members

Tom Bishop, Director, International Fellows Program, National Defense University
Robert Garigue, Department of National Defense, (DISOA), Canada
Gene Lussier, CEO, Team-Serve LLC, Ft. Lauderdale, Fl
Dr. Shunji Noso, President, Teijin America, New York, NY
Brian Russell, Director, North American Policy Group, Dalhousie University, Halifax, Nova Scotia, Canada
Frank Treppe, Vice President and COO, Fraunhofer, USA, Ann Arbor, MI
Jill Watz, Lawrence Livermore National Laboratory, Livermore, CA

II. Team Composition and Preparedness

It was unfortunate that more foreign citizens were not available for the game, and that three of the scheduled players were unable to complete the game. However, the final team members were of sufficient diversity to constitute a very adequate team to represent foreign interests. They also turned out to be very creative and imaginative in the play. The Japanese member of the team was handicapped by English language in the very fast moving play, but was proficient enough that he participated well at times, contributed to the game, and seemed to get some value from the experience.

As I have observed at other games, players probably had not thoroughly read all the pre-game materials, but did generally understand the concept and quickly grasped the most important concepts. As usual, they were somewhat fuzzy on sources and uses of money at various stages of play, but again were very effective in learning quickly and moving decisively. As it turns out, the group really did have the appropriate expertise for their roles. Having a Canadian, a Japanese and a European gave good balance to the American players, and the team was able to truly represent foreign interests.

III. Description of Planning Session

The team was able to move very quickly to establish their roles, priorities and to a lesser degree, their strategies. After some initial discussion, they decided on a dual role, representing both developed and developing countries. Their priorities had a good deal to do with economic development, infrastructure development in developing countries (food, water, transportation and education), access to US markets and technologies, and quality of life issues. They were also able to quickly decide on a set of priorities for Toolkit investments. In the first session, a strong sense of strategy didn't seem to develop. There was some hesitation in seeking or discussing partnerships and coalitions to further their priority objectives, and most of the time was spent in gathering intelligence from other groups and trying to understand how they might develop a strategy.

IV. Strategy Implementation

In the second session, a strategy began to emerge. It was based on the assumption that the flow of technology from the US to the rest of the world would continue unabated, and be driven largely by the marketplace. Further, infrastructure would be developed in the rest of the world through normal trade channels, and assisted through trade surpluses with the US. They should, thus, invest in those policy and technology options which are critical in some parts of the world, and without which US R&D and policy options alone would have little impact. Thus, they focused on clean water and food. Their strategy included a discussion of putting together an appropriate coalition to support their objectives. There was little regard for the DOE or the National Labs anywhere in this discussion, as their resources for partnering were so small as to be irrelevant. They were effective in approaching other groups for partnering (Congress, Control, Universities and Industry).

In later stages of play, their strategy was modified to include investments in sustainable energy and education with a strong emphasis on partnerships. All their strategies and priorities seemed to have a decidedly long-term focus.

V. Level of Strategic Planning

After the initial confusion over developing a strategy to address their priorities, the group seemed to behave strategically at every stage of play. It may be difficult to articulate that strategy, but it was quite effective nonetheless. The injection of the China situation brought out real creativity in the team. Representing the rest of the world, including China and Taiwan, they developed a set of responses, actions and partnership opportunities that were remarkable, and effective in generating many successful partnerships. The foreign team became the center of much attention for some time. They issued a press release which seemed a very appropriate and effective response to what appeared to be unilateral US action by the Congress team with no consultation with the foreign team; and a US centric aspect to much of the play by others.

VI. Team Dynamics

There were two strong personalities in the team initially. One tended to be analytical, intellectual and articulate; the other very tactical and focused. Both were outspoken, but not overbearing. As play progressed, other members of the team became much more interactive. No single player was ever shut out, or in my opinion, insulted by the play or style of others. Natural leadership seemed to emerge in different people, at different times and on different issues. However, throughout the play, one person continued to emerge as a strong and effective member of the team. Minority positions were respected, and those holding those positions were allowed and encouraged to pursue their own deals consistent with the overall priorities of the team.

VII. Team Successes and Failures

The group was very successful in working as a team and developing priorities, tactics and partnerships. They were extremely creative in responding to events of the game, particularly the China situation. They were successful in almost of their Toolkit investments, and these investments were consistent with their priorities. They were less successful in developing an explicit strategy, even though an implicit strategy emerged which helped their overall success. The team was highly successful in representing the interests of the group role they decided to play.

VIII. Suggested Follow-on Activities

The presence on the team of the US representative of the Fraunhofer Institutes presented a real opportunity for further discussion of opportunities for relations with the National Labs if it can be phrased in the context of US benefit.

The R&D Summit was very effective in refocusing the group on the real objectives of the game, and may well produce opportunities for follow-on activities. In particular, the discussion here really clarified two issues: *what are the roles and missions of the DOE labs; and who are their customers.?* The brief discussion of the Council on Competitiveness new report, Endless Frontier, Limited Resources, opened up another opportunity for follow-on activity. The Council plans a number of regional S&T summits to discuss this report, and Lab participation, in part stimulated by the game, would be beneficial.

Appendix I: Foreign R&D Expenditures in the US

Introduction

This white paper was written to provide briefing materials to players on the Foreign team (and other interested players) participating in the Future@Labs.Prosperity game. The intent of the material is to help the players' understanding of the major countries involved and their technology interests.

Reasons given as “extremely important” or “important” by foreign executives for expending R&D resources in the U.S. for all technology areas include “acquiring technology” and “keep[ing] abreast of technological developments”.[1] Other reasons given varied in importance by industry, but included desires to “assist parent company in meeting U.S. customer needs,” “employ U.S. scientists and engineers,” and “cooperate with other U.S. R&D labs.”

Acquisition and maintenance of state-of-the-art technical capabilities by countries and companies follow various methods when trying to gain access to externally developed technological advances. These methods include: importing high-tech products; licensing foreign technical know-how; acquiring companies active in high-technology fields; and encouraging foreign investment. Another very important means of technology transfer is the education of a country's students in foreign institutions. Nations that acquire access to technological advancements through these mechanisms can often accelerate their competency in particular technologies.

Foreign entities interface with various U.S. companies and agencies in several ways. Readily available data concerning these interactions were collected; many areas could likely be expanded, but the scope of this paper was restricted by its relative place in the scheme of the game. The information presented below was collected primarily from reports issued by the Office of Technology Policy, [2, 3] and the National Science Foundation.[4] The data presented in these references come from surveys collected from companies that perform R&D, which are defined to be those companies with R&D expenditures of greater than $1M or having at least 1000 employees on roll (total, not R&D). All reported expenditures are in current (then year) dollars.

Foreign Investments in U.S. Companies

Total Investments

Acquisition of U.S. firms, in part or total, by foreign companies provides one means of acquiring technology (see Figure I-1). Foreign investments in the U.S. total $335B, and are primarily in manufacturing. Obtaining U.S. investments overseas are also important in acquiring technology for the host country since they are often accompanied by requirements for transferring technology through various means including equipment transfers, training, and licensing. Total U.S. investments overseas ($487B) exceed foreign investments in the U.S., and are primarily in manufacturing interests.

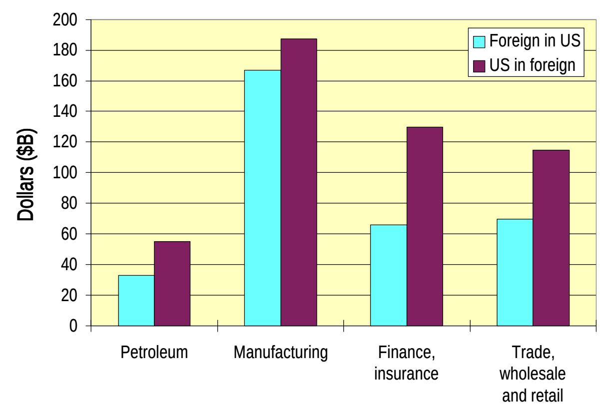


Figure I-1. Comparison of investments between the U.S. and other countries

In assessing the major investors by country, Figure I-2 shows that the United Kingdom is the largest investor, closely followed by Japan. However, if economic blocs are considered, the European Union far outstrips all other investors in the U.S., with Japan and Canada trailing significantly behind.

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[1] Serapio, M. G., Jr., and D. H. Dalton, “Foreign R&D Facilities in the United States,” *Research Technology Management*, Industrial Research Institute, November-December 1993.
[2] Dalton, D. H., and M. G. Serapio, Jr., *U.S. Research Facilities of Foreign Companies*, U.S. Department of Commerce, Office of Japan Technology, Washington, D.C., January 1993.
[3] Dalton, D. H., and M. G. Serapio, Jr., *Globalizing Industrial Research and Development*, U.S. Department of Commerce, Office of Technology Policy, Washington, D.C., October 1995.
[4] National Science Foundation, *Science & Engineering Indicators—1993*, http://www.nsf.gov:80/sbe/srs/seind93/start.htm

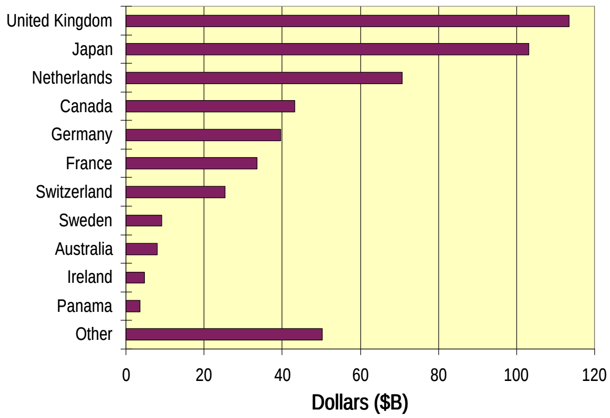

Figure I-2. Foreign investments in the U.S. by country (1994).

U.S. Affiliate R&D

The Department of Commerce defines a foreign-owned business in the U.S. as a U.S. affiliate of a foreign firm in which a foreign parent company owns at least 10 percent of the affiliate's equity. Although acquisition of companies active in high-technology fields is one means for developing and maintaining state-of-the-art technical capabilities, consideration of the actual R&D performed by these acquired companies can provide a better assessment of the technologies of interest.

R&D Expenditures

This section presents data on R&D expenditures by foreign affiliates in the U.S. The available data only represent funds spent at company-operated R&D facilities, and exclude other types of foreign-sponsored R&D, such as research sponsored at U.S. universities or laboratories.

Note: The funding level of the foreign team in the Future@Labs.Prosperity game was scaled to provide an influence level in the game commensurate with the R&D expenditure level of U.S. affiliates of foreign firms as described here.

R&D spending by U.S. affiliates of foreign companies has, in general, increased at a rate of about 15% per year since 1987. This trend is shown in Figure I-3, and 1993 expenditure data is provided by country in Figure I-4. Spending on R&D by affiliates in the U.S. more than doubled from 1987 to 1993, where it stood at $14.6 billion. These data indicate that expenditures by affiliates have increased much faster than total R&D expenditures by U.S. firms (percent of share increasing). Of the total R&D performed by affiliates, 95% is financed by the affiliates themselves, with 4% coming from contract work for other private companies and 1% from the federal government. [5]

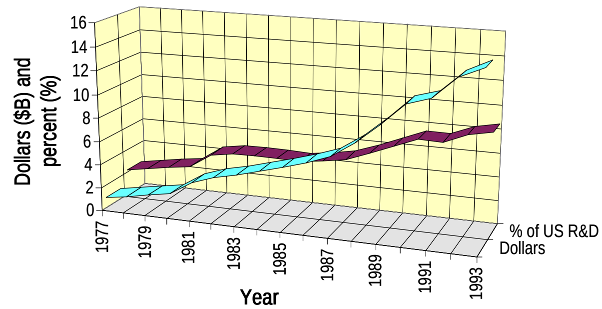

Figure I-3. Trends in R&D Expenditures by Affiliates in the U.S.

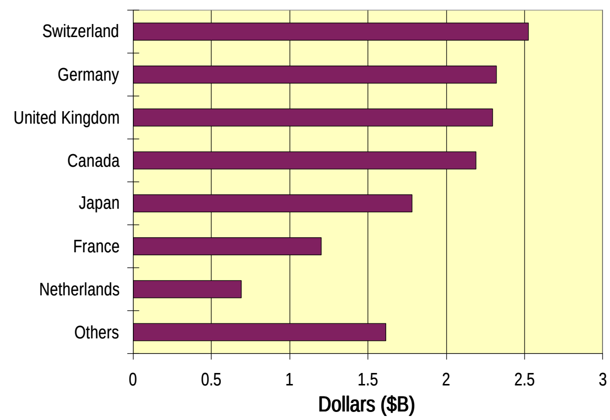

Figure I-4. R&D Expenditures by Country for U.S. Affiliates of Foreign Companies (1993)

The R&D expenditures shown in Figure I-3 and Figure I-4 provide a measure of the influence that foreign companies play in U.S. R&D, but they do not provide a picture of foreign technology areas of interest and the major role these companies play in certain industries. For example, in the high-technology sector, 20% of the money spent on corporate R&D is by a foreign company. A more detailed breakout illustrating areas of primary R&D expenditure by foreign affiliates is provided in Table I-1.

[5] Zeile, W. J., "Foreign Direct Investment in the United States: 1992 Benchmark Survey Results," *Survey of Current Business*, Bureau of Economic Analysis, July 1994, pp. 154-186.

Table I-1. Percentage of high-technology industry R&D expenditures by US affiliates.

Industry	Percent of total R&D
Industrial Chemicals	45.2
Drugs and medicines	38.2
Computers and office equipment	7.2
Audio, video, communications	33.0
Electronic components	8.2
Scientific and professional equip.	7.9

Foreign-Owned R&D Facilities

R&D Facilities

A foreign R&D facility is defined by the Department of Commerce to be a freestanding R&D company site (i.e., a facility engaged mainly in R&D) of which 50 percent or more is owned by a foreign parent company. Data on foreign-owned facilities thus represent a subset of the data presented above. R&D departments or sections within the U.S. affiliate companies were excluded from the survey data. The number of facilities is broken down into technology area and country in Figure I-5 and Figure I-6 below. The 'other' category in Figure I-5 includes the Netherlands (26), Sweden (22), Canada (8), Italy (8), Finland (5), and thirteen additional countries. Based on the data of Figure I-2 and Figure I-4, we may infer that the Japanese prefer to keep more of their R&D facilities separate from other corporate functions compared to their European counterparts. European companies in general go for larger, fewer R&D facilities, while the Japanese build smaller, single technology facilities (sixteen of the largest foreign research centers are owned by European countries while Japan has three; the other is Canadian). The data also show that there are more Japanese parent companies represented in the U.S. compared to any other country. The 645 foreign R&D facilities described in these figures represent 306 companies, and are located across 30 or more states (1994 data); most are located near concentrations of R&D facilities of U.S. companies and near research universities. (For reference, in 1992 there were a total (U.S. and foreign owned) of 36155 companies in the U.S. "performing" R&D[6].)

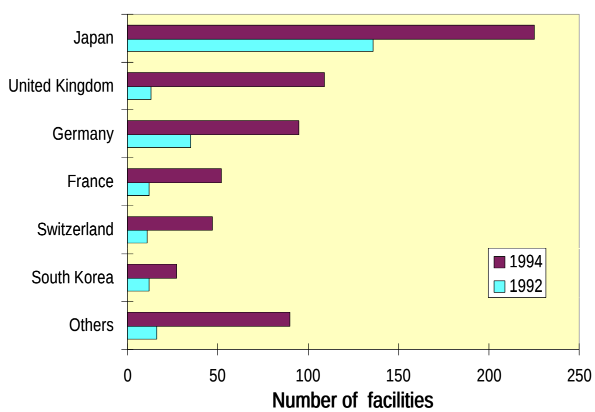

Figure I-5. Freestanding Foreign-Owned R&D Facilities In The U.S. By Country

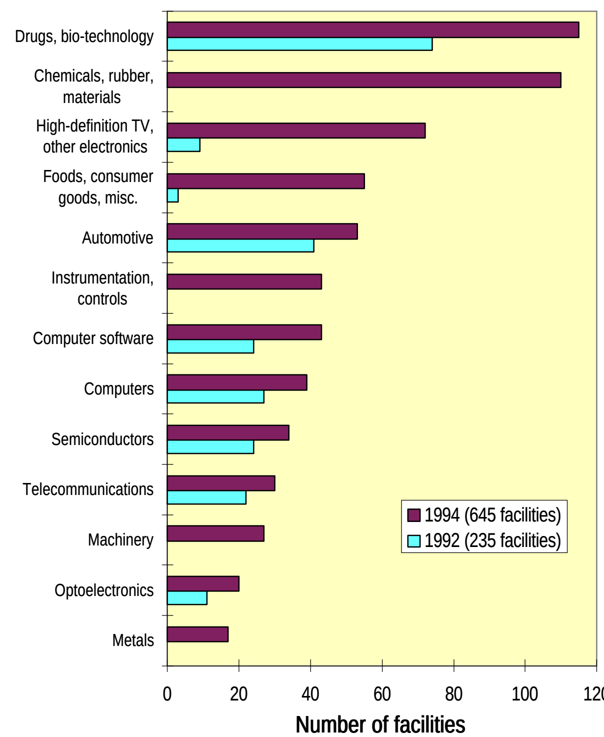

Figure I-6. Freestanding Foreign-Owned R&D Facilities In The U.S. By Technology Area

R&D Expenditures

R&D expenditures by year for foreign R&D facilities (from the NSF data) are presented in Figure I-7. It should be noted that these data are a subset of total foreign R&D expenditures in the U.S., and that they exclude expenditures for R&D conducted by others (U.S. owned companies, consortia, universities, government laboratories, etc.) under contract. When the R&D expenditures of foreign-owned companies are compared to the R&D spending of foreign affiliates (see Figure I-3), it can be seen that approximately 75% of the foreign R&D funds in the U.S. are controlled by foreign-owned R&D facilities.

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[6] National Science Foundation, *Research and Development in Industry: 1992*, NSF 95-324 (Arlington, VA, 1995). http://www.nsf.gov/sbe/srs/s2492/

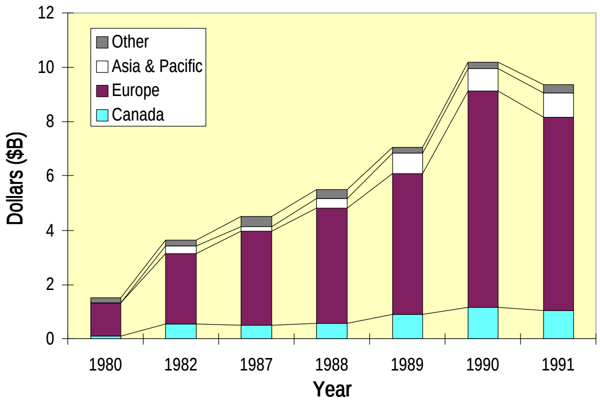

Figure I-7. R&D Expenditures by Majority-owned Foreign Companies in the U.S.

Contract research

Foreign countries, companies, and U.S. affiliates are all known to contract for R&D within the U.S. Examples would include foreign-sponsored research at U.S. universities, at U.S. company or consortia labs, and at U.S. government laboratories. However, no data were found to describe the scope of foreign-sponsored R&D other than that presented above for affiliate-company (including majority owned) in-house work.

Company R&D contracted to outside organizations

Limited data on outside contracting behavior of U.S. firms (including affiliates) are available from the National Science Foundation.[7] In 1991, U.S. industry spent some $4.3B on R&D contracts to outside organizations (this amounts to 3.7% of the total U.S. R&D expenditure). Of this amount, $1.2B went to universities,[8] while the remainder would have been split in some unknown fashion between private (e.g., other company or consortia labs) and government concerns. This suggests that $500M of affiliate moneys are spent on R&D in the U.S. outside of their own facilities (exclusive of universities), assuming an equal percentage split.

University Research

If it is assumed that splits in funding equivalent to the total R&D expenditure profile hold true for contracts, of the $4.3B sent to universities and colleges by industry, some $645M was provided by foreign affiliates. However, since affiliates control a larger share of the high-technology sector (where universities tend to conduct their research) and display a propensity for locating near research universities, the actual amount may be much higher (closer to $1B). Foreign governments appear to play little direct role in contracting with universities to conduct research. Figure I-8 illustrates trends in funding sources for R&D at universities and colleges.[9] Of these categories, only 'all other sources' would appear to allow for non-company foreign investment, but this is generally attributed only to non-profit organizations.[10]

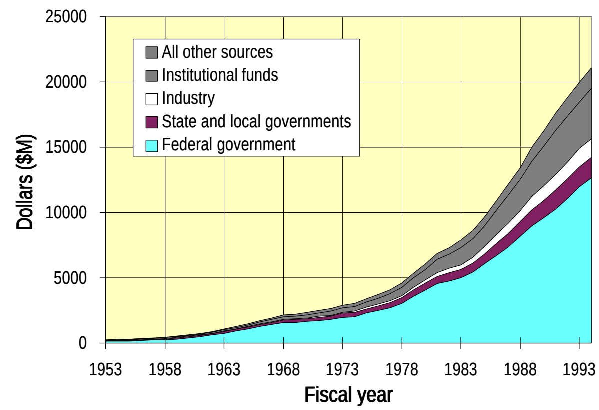

Figure I-8. R&D Expenditures at Universities and Colleges by Source of Funds

FFRDC Research

No published data concerning foreign R&D contracts with FFRDCs were found. To provide an estimate of this category, Sandia National Laboratories FY96 foreign 'work-for-others' programs were evaluated (e.g., a linear extrapolation of costs-to-date indicate that approximately $5M per year is currently spent at Sandia on foreign government and company sponsored R&D; this is expected to grow from planned work with the Russian Institutes). Considering the number and type of FFRDCs, this suggests that something on the order of $50M to $100M of foreign R&D money is spent annually in federal labs (< 1% of total).

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[7] National Science Foundation, *Research and Development in Industry: 1991* http://www.nsf.gov:80/sbe/srs/s2491/start.htm

[8] National Science Foundation, Academic Science and Engineering R&D Expenditures, FY 1994 http://www.qrc.com/nsf/srs/rdexp/94dst/start.htm

[9] National Science Foundation, Academic Science and Engineering *R&D Expenditures, FY 1994*, http://www.qrc.com/nsf/srs/rdexp/94dst/start.htm

[10] National Science Foundation, *National Patterns of R&D Resources, 1995 Data Update*, http://www.nsf.gov/sbe/srs/s2195/start.htm

Patents and Licenses

Nearly half (47 percent in 1991) of all patents granted in the United States are to foreign interests (corporations, 82%; individuals, 11%; foreign governments, 1%). Foreign patenting is highly concentrated by country of origin, with just five countries--Japan, Germany, Great Britain, France, and Canada--accounting for 80% in 1991.

Licensing transactions between unaffiliated firms tend to reflect the value of technological know-how exchanged. Data for Asia, shown in Figure I-9, indicate that it is clearly a net importer of U.S. technology.[11] Data were not located for other countries or regions, but it is likely that a similar situation exists, although perhaps not to the same degree of imbalance.

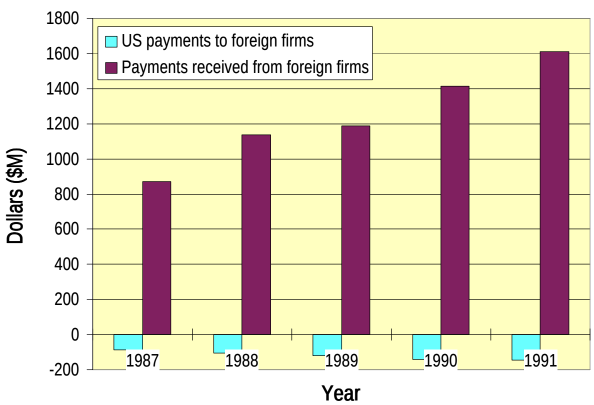

Figure I-9. Licensing Technology Activity: U.S. - Asia

High-Tech Product Purchasing

Purchases of products that contain cutting-edge technologies account for over one-quarter of all merchandise purchased from the United States by Asia (over $30B of high-tech in 1991). Similar import trends exist for high-tech U.S. products in other countries. Technology fields of highest interest include aerospace, optoelectronics, biotechnology, electronics, computers, telecommunications, and weapons.

Foreign Students

Another way to assess foreign interests in U.S. R&D is to evaluate trends in graduate student citizenship and fields of study. Foreign full-time science and engineering (S&E) students now account for over 30% of the population in U.S. post-graduate schools, up from 22% in 1980.[12] The growth in foreign graduate students in S&E is illustrated in Figure I-10. Although the majority of funding for foreign students in the U.S. at all levels of higher education is from non-U.S. sources (family, 64%; home government or other sponsors, 9%), the situation is quite different if only doctoral S&E students are considered. U.S. sources provide the primary funding support for 80 percent of all foreign doctoral S& E students in the form of either research assistantships (RAs, including some research funds to universities from federal grants), teaching assistantships (TAs), or university fellowships. Three percent comes from federal fellowships or traineeships. (For U.S. citizens, only about half of the primary support is in the form of RAs, TAs, and university fellowships, about 13 percent is from federal fellowships and traineeships, and the remaining third is self-support.)

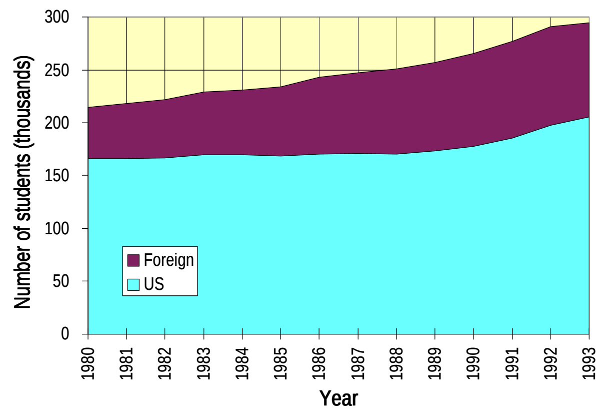

Figure I-10. Full-time Science and Engineering Graduate Students by Citizenship

Because foreign interests do not necessarily follow those of U.S. citizens, a clearer technology acquisition picture can be achieved by considering student population as a function of field of study. Such information is provided in Figure I-11. From this figure it can be seen that foreign students almost equal the number of U.S. students in many areas, with the most notable exceptions being the fields of psychology and health. Eliminating these two subjects from consideration increases the percentage of foreign S&E graduate students to 34%. These high percentages are somewhat offset by the fact that 40% or more of the foreign doctoral recipients remain in the U.S., as shown in Figure I-12.

[11] National Science Foundation, Asia's New High Tech Competitors, NSF 95-309, http://www.nsf.gov/sbe/srs/s4495/conten1b.htm

[12] National Science Foundation, *Selected Data on Graduate Students and Postdoctorates in Science and Engineering: Fall 1993, Supplementary Data Release Number 7: by Citizenship*, (Arlington, VA, 1995). http://www.qrc.com/nsf/srs/gss/93supp/sup07/sup07.htm

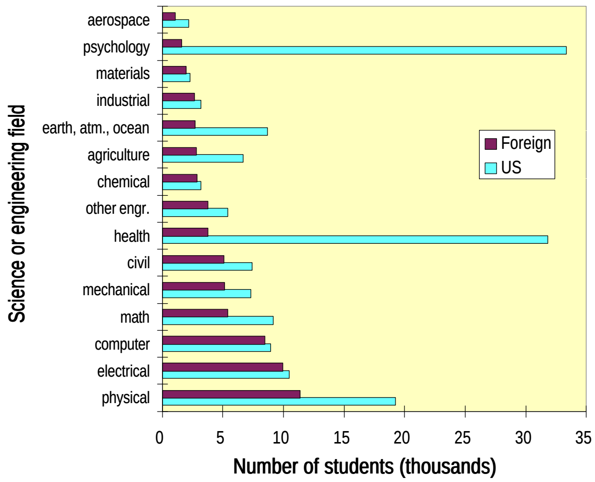

Figure I-11. Full-time Science and Engineering Students by Field of Study and Citizenship (1993)

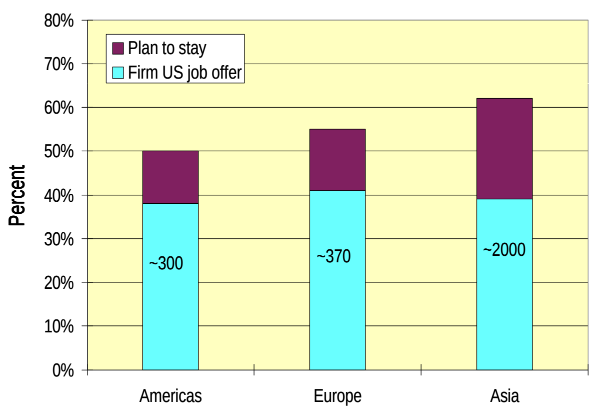

Figure I-12. Number and status of foreign doctoral recipients: 1991

Industrial Espionage

Acquisition and maintenance of state-of-the-art technical capabilities by countries and companies may employ other than legal means to gain an advantage. "An increasing share of espionage directed against the United States comes from spying by foreign governments against private American companies aimed at stealing commercial secrets to gain a national competitive advantage." [13] "Each day America becomes driven more and more by information. Proprietary information is our chief competitive asset … [T]he need to protect economic information looms even larger … [because of] strenuous efforts on the part of some foreign intelligence agencies to benefit their national industries."[14] In 1988, 48 percent of all high-technology companies surveyed admitted to being the victim of industrial espionage.[15] Between 1985 and 1994, incidents of foreign-sponsored proprietary business information theft increased 400 percent.[16] The U.S. pharmaceutical and chemical industries lose on the order of $10B per year to overseas counterfeiters.[17] The French, Germans, Israelis, Koreans, Japanese, British, and Canadians have all targeted U.S. industries for intelligence collection. Former FBI Director William Sessions told a house subcommittee that "Russians do not have the currency to pay for advanced systems and designs, so they will steal them or obtain them through other illegitimate means."[18] The problem is not just limited to large countries with well established intelligence agencies. "Some fifty Third World countries [are] now able to operate [espionage activities] …" [19] Reportedly, foreign students are often tasked as part of these efforts.[17]

[13] Boren, Senator David, Speech to the National Press Club, April 3, 1990.

[14] U.S. Department of State, *Publication 10017*, November 1992.
[15] University of Illinois, *A Study of Trade Secrets in High-Technology Industries*, 1988.
[16] Schwartau, Winn, *Information Warfare*, Thunder's Mouth Press, 1994.
[17] Schweizer, Peter, *Friendly Spies*, Atlantic Monthly Press, 1993.
[18] Mello, J.P., Jr., "Espionage! Are the Spooks Targeting Your Business?" *ISP News*, Volume 3, Number 5, September/October 1992.
[19] Gates, CIA Director Robert, Congressional testimony, April 29, 1992.

Appendix J: Defense Preparedness Briefing

Introduction

The Future@Labs.Prosperity game has a set of specific objectives including one to:

> *"Explore ways to optimize the role of the multidiscipli nary labs [DOE] in serving national missions and needs.[1]"*

Since one major national mission has always been defense, a metric was needed in order to evaluate game play in terms of the impact that R&D investment decisions might have had upon that mission. This measure of the U.S. defense preparedness met several provisos including:

1. The effort expended in model development was very limited.
2. The model scope reflected its relative place in the scheme of the game (the focus is on R&D investment, collaboration, and partnering strategies).
3. The model supported player feedback during the game play without significant impact on the Control team's resources.

The resulting defense preparedness metric model is simple, uses readily available data, and is able to reflect the outcome of game play.

The model was based on a distillation of the writings of Clausewitz on strategy,[2] where the outcome of combat is affected by three factors:

1. the number of combatants;
2. the quality of combatants;
3. other factors related to the purpose and circumstances of the combat.

Into the last factor can be grouped government policies (to which war is subservient), genius in leadership, providence, morale, and other such real influences which will *not* be treated in this model. That leaves two factors: numbers of combatants and their quality. These two measures can be combined as a product to give a strength or power factor. Calculating a strength ratio between any two groups will provide a measure of their relative strength.

To assess the first factor, the number of combatants, the total number of uniformed personnel in each country's armed forces was assumed to be an adequate measure. No attempt was made to separate combatants from support personnel.

Ideally the second factor, the quality of combatants, would include an explicit assessment of combat performance as supported by sub-factors such as operational training, equipment capabilities and availability, etc. However, assessments of operational readiness are likely to be classified (and thus unsuited for this game format), and acquiring and assessing various country's equipment lists (orders of battle) would require resources not available for this game. Rather, this analysis will generate a first-order assessment of the quality of the combatants by comparing expenditures on equipment (procurements, maintenance, and R&D expenditures). The premise here is that more money spent on equipment means better outfitted combatants, and thus higher quality combatants.

U.S. versus ….

Although the U.S. strength could have been played off against a potential adversary list, the need of the game was to develop a metric to indicate the relative trend of U.S. defensive force preparedness. However, this still requires that the U.S. forces be compared against some country or group. Two groups were selected: NATO (U.S. vs. the rest of NATO), and the top ten economic producers (as measured by GDP; since the U.S. fell into this group, this is really a comparison of the U.S. vs. the other nine).

NATO Comparison

Number of Combatants

U.S. Military Manpower. Data on U.S. military manpower levels for the years 1950 to 1995 were downloaded from the U.S. DoD Directorate For Information Operations and Reports.[3] An extrapolation of manpower levels for the years 1996 to 2005 was carried out based on a linear decrease to Institute for National Strategic Studies projected force levels for 1999, [4] followed by constant force levels (may be conservatively high). The actual and projected force levels are shown in Figure J-1.

NATO Military Manpower. Personnel data for NATO forces were collected and extrapolated at a constant level. NATO reportedly has no plans for arms reductions over

[1] *Future@Labs.Prosperity* Prosperity Game Players' Handbook

[2] Clausewitz, Carl von, 1832, *Vom Kriege* (On War), Book Three, Chapter Eight, trans. J.J. Graham 1908, Pelican Books 1968 edition.

[3] http://web1.whs.osd.mil/mmid/military/miltop.htm

[4] http://www.ndu.edu/ndu/inss/sa95/sa95cont.html

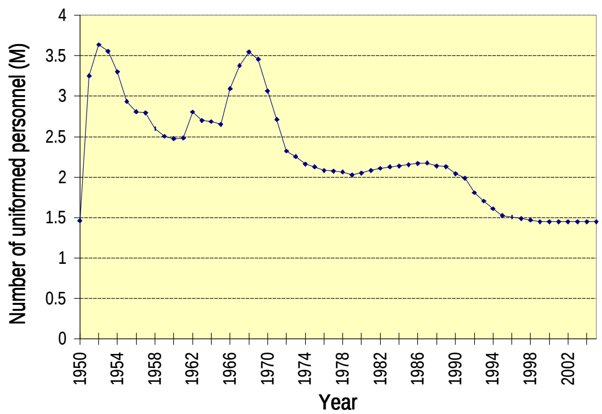

Figure J-1. US military personnel levels.

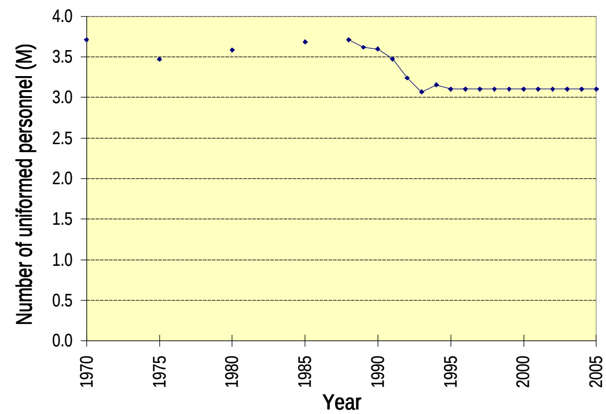

Figure J-2. NATO personnel levels (European and Canadian only).

and above those of the early '90s. [5] [6] On the contrary, with the end of the Cold War, existing institutions in Europe, such as the EU, WEU and OSCE, are pursuing an opportunity to build an improved security architecture. [7] The aim of this architecture is to provide increased security for all in the Euro-Atlantic area by inviting former Eastern-Bloc countries to become Allies. Referred to as "NATO enlargement," this process will extend to new members the benefits of common defense and integration into European and Euro-Atlantic institutions. This enlargement is currently projected to cost the Western states alone some $7B to $70B,[6] depending upon the final architecture. These expenditures, along with those by the new member countries themselves, will be used for the necessary infrastructure and equipment upgrades to enable effective force integration. However, we have not considered this NATO enlargement in developing a defense preparedness metric for this game. The available historical and projected out-year (flat) NATO manpower levels are shown in Figure J-2.

Defense Expenditures (U.S. vs. NATO)

U.S. Defense Expenditures. Historical data and near term projections of total U.S. defense spending were available from the President's budget.[8] The average of the budget projections for 2001 and 2002 was used as the spending level for 2003-2005. Historical equipment (including R&D) spending levels were available from NATO documents.[5] Projected equipment spending was based on an average percentage of the total budget for recent years. These data sets are provided as a bar chart in Figure J-3.

NATO Defense Expenditures. European NATO and Canadian defense budget and equipment expenditures (including R&D) were also extracted from NATO documents.[5] Out-year projections have used the present as a baseline (no planned reductions[6]) with only a mild 3% inflation rate (actual 1994 weighted average was 7%). As mentioned under the manpower section, the predictions of NATO enlargement into Eastern Europe have been ignored. Currency conversion utilized data primarily from the Penn World Tables (Mark 5.6),[9] supplemented as necessary by CIA,[10] Federal Reserve,[11] and other Internet resources.[12] The results are plotted in Figure J-4.

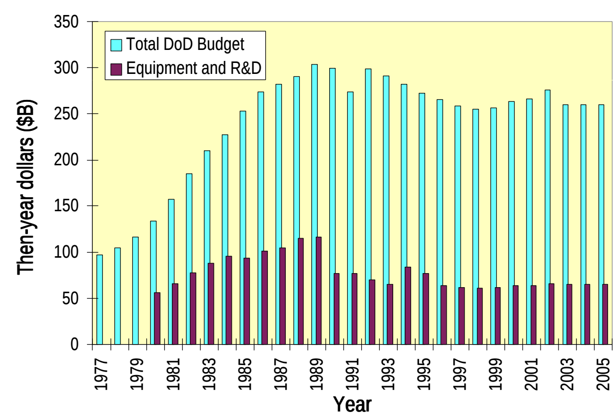

Figure J-3. US military budget.

[5] gopher://marvin.stc.nato.int:70/59/natodata/PRESS/BUDGET/ pr92-100 and .../pr95-115 (zip files)
[6] http://www.igc.apc.org/basic/pressnatoexp.html
[7] http://www.nato.int/docu/basictxt/enl-9501.htm
[8] http://www.doc.gov/BudgetFY97/hist/hist04z1.wk1
[9] http://www.epas.utoronto.ca:5680/pwt/pwt.html
[10] http://www.odci.gov/cia/publications/95fact/index.html
[11] http://www.stls.frb.org/fred/data/exchange.html
[12] http://www.olsen.ch/cgi-bin/exmenu

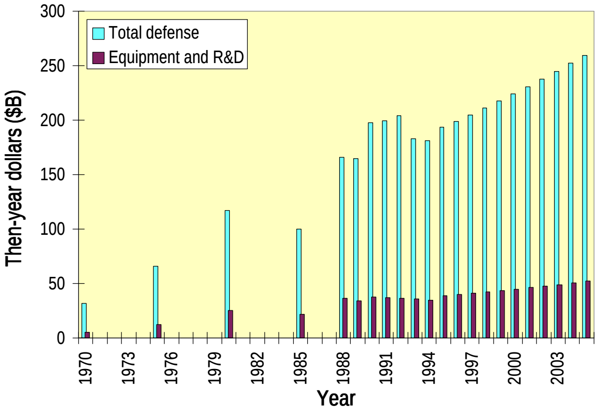

Figure J-4. NATO military budget (European and Canadian only).

Strength Ratios (U.S. vs. NATO)

U.S. vs. NATO Force Ratios. The manpower data presented above were combined to give a ratio of the relative force strengths between the United States and NATO. This ratio is plotted by year in Figure J-5. The decreasing trend clearly shows the post-Vietnam and post-Reagan (or post-Cold War) manpower reductions, as partially offset by European NATO post-Cold War force size adjustments.

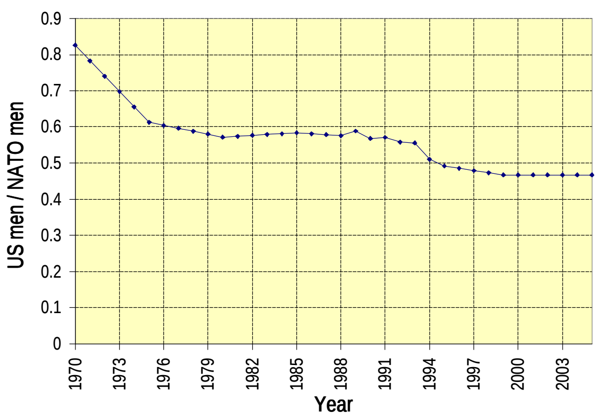

Figure J-5. US to NATO force ratio.

U.S. vs. NATO Defense Expenditure Ratios. Budget data were likewise compared as part of developing the relative strength ratio. Although only the equipment portion of the budget will be used in this fashion, a total budget ratio is provided for reference. Both ratios are plotted in Figure J-6. Two points can be made: (1) both ratios display the same basic trends, generally only differing in magnitude; (2) the data indicate that the U.S. spends a

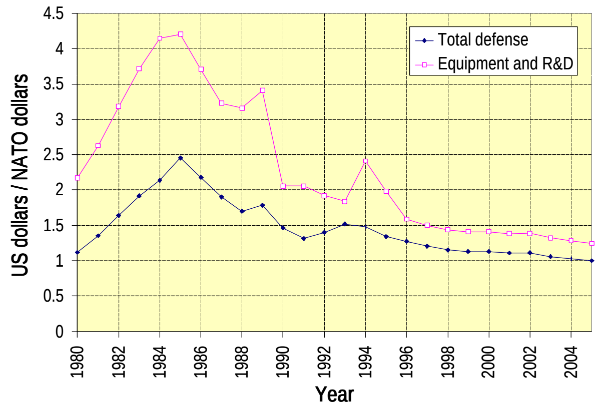

Figure J-6. US to NATO military budget comparison.

larger fraction of its budget on equipment (the upper line is the equipment expenditure ratio). This is in keeping with the U.S. reliance on having technological superiority to offset numerical inferiority in a conflict.

U.S. vs. NATO Strength Ratios. Multiplying the force ratios and equipment expenditure ratios together then gives the desired strength ratio, as provided in Figure J-7.

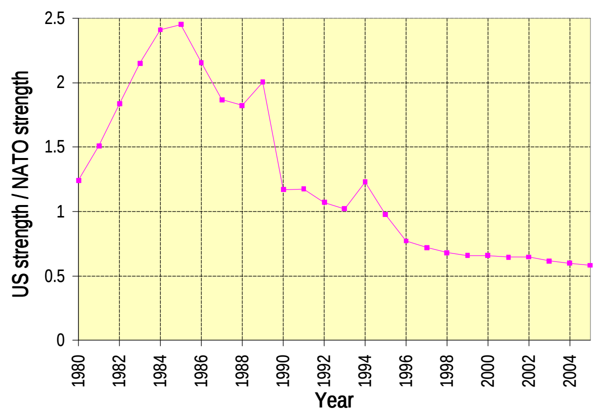

Figure J-7. US to NATO relative strength comparison.

Major World Producer Comparison

The top ten economic producers, as defined by their GDP, were selected for the second strength comparison. The actual GDP comparisons were conducted using information from the 1995 CIA *World Factbook*.[10] The countries on the top ten list were: Canada ($552B); China ($545B); France ($1,253B); Germany ($1,880B); Iran ($1,014B); Italy ($1,000B); Japan ($4,216B); Spain ($478B); United Kingdom ($944B); and the United States ($6,738B). Since the U.S. is on this list, the actual comparison will be against the other nine countries.

Number of Combatants

U.S. Military Manpower. U.S. active duty personnel levels used for this comparison were the same as for the NATO comparison.

Major Producer Manpower. Personnel statistics for those major producers that are members of NATO also were drawn from the work presented above. Data on military manpower levels for China, Iran, and Japan were gathered from publications of the International Institute For Strategic Studies[13] and the U.S. Army Area Handbooks.[14] Out-year extrapolations for China, Iran, and Japan followed recent trends observed in the data (China decreasing). The composite trends in manpower levels are shown in Figure J-8.

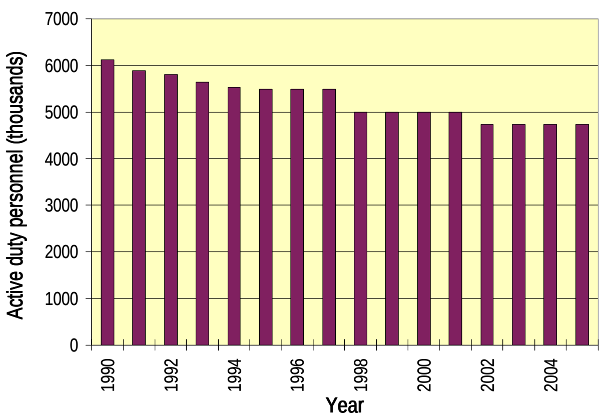

Figure J-8. Major economic producers' military manpower.

Defense Expenditures (U.S. vs. Major Producers)

U.S. Defense Expenditures. U.S. budget levels used for this comparison were the same as for the NATO comparison (Figure J-3).

Major Producer Manpower. Applicable defense expenditure data collected for the NATO comparison was used here for those major producers that are NATO members (data supporting Figure J-4). However, details on the breakout of those portions of defense expenditures spent on equipment could not be found for China, Iran, and Japan. Therefore, this comparison was made based on total defense spending. Since it was observed that equipment spending and total expenditures followed the same general trends in the NATO comparison (see Figure J-6), use of total defense spending should still provide a useful indicator of U.S. defense trends. Defense expenditure data for China, Iran, and Japan were collected from the 1991,[15] 1992,[16] 1993,[15] 1994,[17] and 1995[10] CIA *World Factbooks*, from on-line Stockholm International Peace Research Institute data,[18] and gathered from publications of the International Institute For Strategic Studies.[13] Currency conversion, where required, utilized the same resources as documented in the NATO comparison. The compiled results, in U.S. dollars, are provided in Figure J-9.

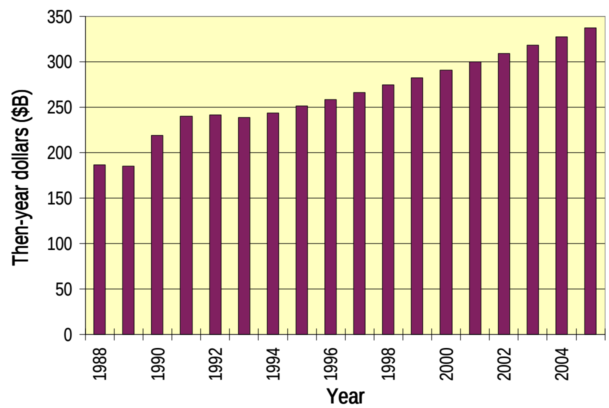

Figure J-9. Major economic producers' military budget.

Strength Ratios (U.S. vs. Major Producers)

U.S. vs. Major Producers Force Ratios. The manpower data presented for the U.S. (Figure J-1) and the other major economic producers (Figure J-8) were combined to give a ratio of the relative force levels. This ratio is plotted by year in Figure J-10. The initial decreasing trend illustrated, caused by the rapid reduction in U.S. personnel in the early '90s, is eventually offset by continued assumed reductions in Chinese manpower (see IISS reports[13]).

U.S. vs. Major Producers Defense Expenditure Ratios. A comparison of the US (Figure J-3) and other major producers (Figure J-9) defense expenditures is provided in Figure J-11. The trend shown is not unlike that found in the NATO comparison (Figure J-6), and is driven primarily by the continued US reduction in real dollars budgeted for

[13] IISS, *The Military Balance*, Oxford University Press, London, publication date issues of 1990 to 1995.
[14] gopher://gopher.umsl.edu:70/11/library/govdocs/armyahbs/
[15] gopher://cheops.anu.edu.au:70/11/Socioinf-query/WorldFactBook
[16] gopher://gopher.ces.ncsu.edu:70/11/./.ftp/pub/docs/international/worldfactbook
[17] gopher://hoshi.cic.sfu.ca/11/dlam/cia
[18] http://www.sipri.se/

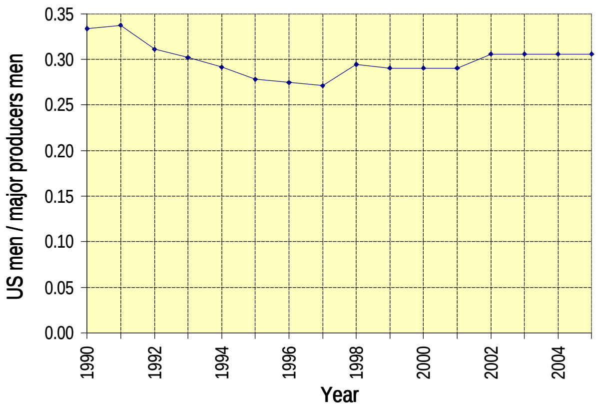

Figure J-10. US to major producers force ratio.

defense (little or no growth in out-years to offset inflation effects).

U.S. vs. Major Producers Strength Ratios. Combining the force ratio and expenditure ratio data yields the desired strength ratio. The results are plotted by year in Figure J-12.

Game Metrics

Normalized Strength Ratios. Either of the projected trends in the strength ratios given in Figure J-7 and Figure J-12 above could be used as a baseline metric to represent U.S. defense preparedness for the game. For comparison, the 1990 and later strength ratios from both the U.S.-vs.-NATO and U.S.-vs.-Major Producers results are provided in Figure J-13, normalized to 1992. This illustrates the fact that both comparisons produced similar results.

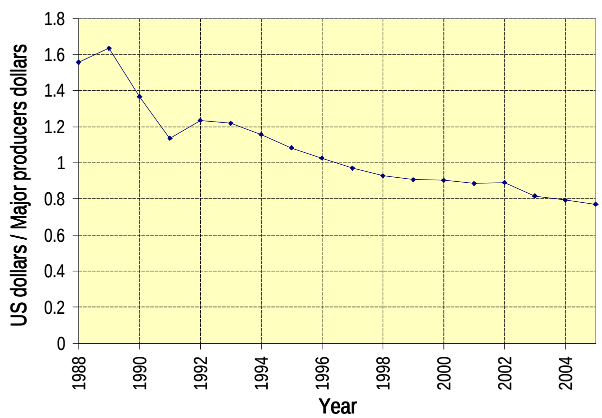

Figure J-11. US to major producers military expenditure comparison.

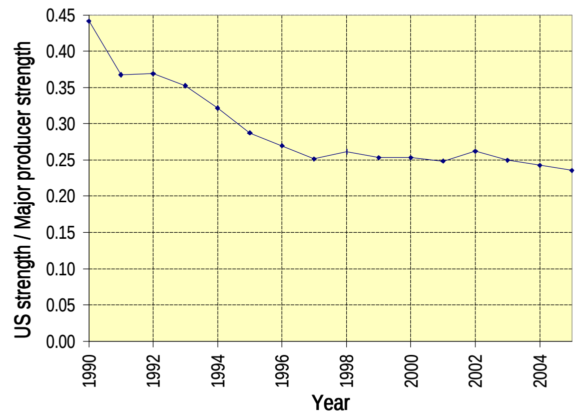

Figure J-12. US to major producer relative strength comparison.

Averaged Strength Ratios. Rather than select one comparison over another, the results were averaged, as shown in Figure J-14. These averaged results were then chosen as the baseline defense preparedness metric to be used in the *Future@Labs.Prosperity* game.

Game Play Effects. Alteration of this metric during the game could occur as a result of R&D expenditure decisions (departures in spending on defense, non-defense, or joint-use technology options from the baseline budget). Historical and near-term proposed U.S. R&D spending trends are available from the President's 1997 Budget, [19] and are shown in Figure J-15. Recent trends indicate that approximately 54% of the R&D budget should be

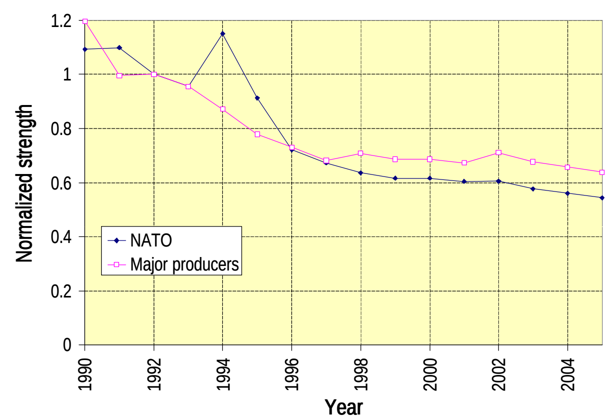

Figure J-13. Normalized strength comparison data.

allocated to defense related issues. However, since game money may not necessarily be allocated with in-play levels

[19] http://www.doc.gov/BudgetFY97/hist/hist09z1.wk1

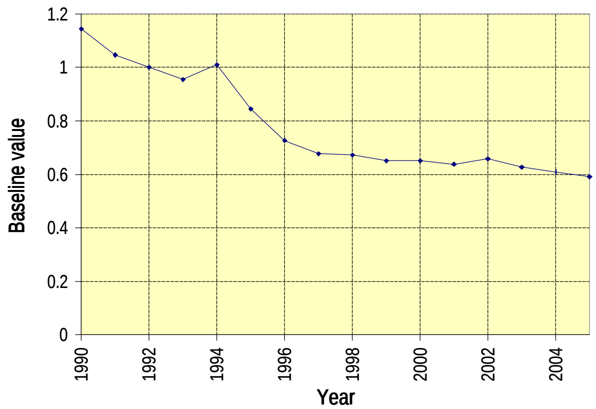

Figure J-14. Prosperity Game defense posture metric.

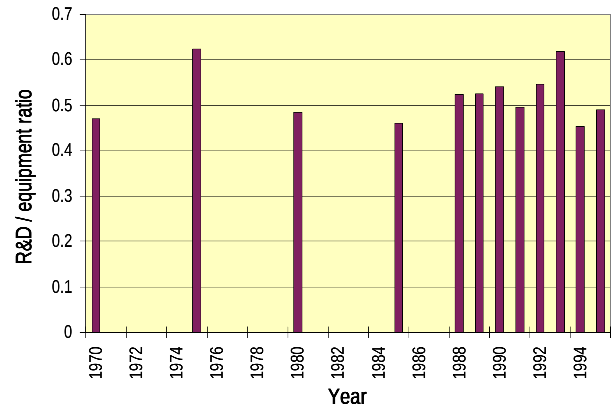

Figure J-16. R&D versus total equipment expenditures.

equal to projected real levels, this percentage may have to be adjusted in order to have an equivalent effect (preliminary game plans call for a value of 45%).

In order to link the R&D expenditures with the strength ratio, the U.S. defense R&D expenditure data can be compared to the previous equipment expenditure data (NATO section; recall that it includes R&D). From such a comparison it can be seen in Figure J-16 that roughly one-half of the U.S. equipment expenditure effect on the strength ratio is due to R&D. (It is fully recognized that R&D expenditures do not, in reality, have an immediate effect upon fielded weapons. DARPA funding generally looks at technologies with payoffs 5-15 years out, while various Systems offices concentrate on technologies that can be demonstrated in 2-3 years.[20] R&D lag effects on the

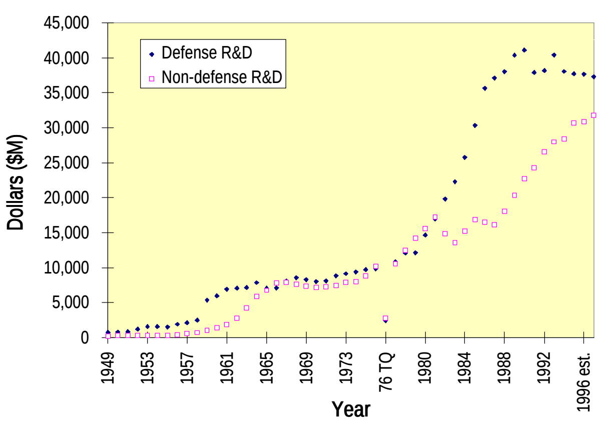

Figure J-15. US R&D expenditures.

strength ratio would be somewhat offset if R&D funding was fairly stable. However in any case, it is unlikely that any reasonable assessment of these effects could be incorporated into this model in a meaningful way, and the simple approach – ignoring the effect – was taken.)

Then, using the following notation:

1. the projected fraction of the government R&D budget spent on defense is given by α (from Figure J-15 or other game metric)
2. the projected fraction of the equipment budget spent on R&D is given by β (e.g., estimate from Figure J-16)
3. the baseline set of defense preparedness metrics for the years of the game is given by $p_1, p_2, \ldots p_i$ (from Figure J-14)
4. the baseline set of government R&D funds for the years of the game is given by $g_1, g_2, \ldots g_i$ (from game plans)
5. the actual amount of government R&D funds spent on defense related technology options during game play is given by $s_1, s_2, \ldots s_i$ (from game play)

a revised defense preparedness metric can be calculated by:

$$p_i' = p_i\left[1 - \beta\left(1 - \frac{s_i}{\alpha g_i}\right)\right]$$

If a value for β of 0.5 is used, this equation reduces to:

$$p_i' = \frac{p_i}{2}\left(1 + \frac{s_i}{a\ g_i}\right)$$

It can be seen that this relationship is linked to the game focus of R&D investment. Other changes that could be

[20] Eisele, Anne, "Newest DARPA Initiatives Focus On MEMS Dust, Anti-Biowarfare," in *New Technology Week*, Vol. 10, No. 4, 01 April 1996, p.1 ff.

implemented by “Congress” during game play may or may not be accommodated by this equation. For example, changes in total government R&D funds (due to tax rate changes, industry profit fluctuations, etc.) are handled by this equation since such changes affect the amount of government R&D funds spent on defense. A mandated change in force structure (number of active duty personnel) would have to be accommodated separately (simply the ratio of new-to-old times the baseline metric). Unforeseen changes will have to be assessed for possible impact on the metric during actual game play.

Appendix K: Prototype Game Results

Introduction

A prototype of the Future@Labs.Prosperity Game was held March 21-22, 1996 in Albuquerque, NM. The purpose of the prototype was primarily to check out the process and try new ideas; i.e., to debug the game. An equally important purpose was to add or clarify appropriate content (e.g., are the proper stakeholders represented, are the Toolkit options relevant, etc.). Two weaknesses in this prototype were the even more compressed time (one day shorter) and the fact that most players were lab employees rather than actual representatives from the stakeholder groups. Nevertheless, the prototype provided a great deal of information that was used to improve the real game, and stimulated significant changes in individual attitudes. Highlights and lessons learned from the prototype game are given in this section.

Team Highlights

In general, the teams were very productive, as evidenced by the number of agreement they generated. Due to the time pressures of the game, very few strategies were fully developed. However, a great deal of partnering was evident in the play. High priorities were assigned to the following areas: education, biomedicine, information surety, criminal justice, science-based regulations, clean water initiatives, and national security.

US Public

- Successful at defining major areas of focus: energy, natural resource preservation, job creation, affordable health care, safe neighborhoods
- Toolkit and subsequent negotiations focused mostly in two areas: energy/environment, education/job creation
- Proposals from other teams were evaluated in terms of how they affected the public's interests

US Congress

- Team focus was on balancing the budget, national defense, and economic well-being
- Became less and less strategic as the game progressed; little long-term thinking
- Team dynamics deteriorated under time pressures
- Congress was thrown out in an ad-hoc election
- The new Congress brought special interests and helped each other get initiatives accepted; made decisions quickly (there was little time left when the election took place)

US Industry/Companies

- Decided to act as one company with attention to many sectors, rather than act as a group of industries
- Focus was 'Integrated Technology and Information Services'
- Felt they had little in common with the labs
- By spending a lot of time working the Toolkit, they came up with initiatives for the future

US Industry/Consortia

- Worked to force privatization of labs
- Critical in forcing an election of new legislative officials

Department of Energy

- A main strategy was to divest itself of the environmental cleanup mission, but no one else would take it
- Information generated during the strategy session was used throughout the game and revisited periodically to make sure the team was moving in that direction
- Successful in working on agreements in defense, energy, and environmental areas
- In times of shrinking budgets, DOE favored NS Labs budgets over S&T Labs budgets (2:1)

Other Federal Agencies

- Focus more on DoD than other agencies
- Played the Toolkit in a reactive mode; investments didn't line up with strategies but rather with where they could partner
- Had great concern over protection of intellectual property (especially defense-related) from foreign interests

Universities

- Laboratory staff had a difficult time putting themselves in the University role

- Team seemed to be more comfortable with tactical rather than strategic planning, and lost track of their strategies when making deals
- Partnership priority was with industry rather than the labs or government agencies

DOE National Security Labs

- Disorganized at the start resulting in a slow, passive, reactive mode of operation in the early going
- Worked together effectively as a group of three labs rather than as separate entities
- Came together very well as a team and became very active when their existence was threatened (and when the defense readiness metric went down)
- Maintained the integrity of the weapons program
- LLNL did not survive as an NS lab, but was successfully privatized
- Learned that they did not have strong arguments against closing laboratories

DOE Civilian S&T Labs

- Players were not well prepared, didn't understand the mechanics, and needed encouragement to get started
- Play was typically reactive and comprised a collection of independent actions (*Carpe diem!*)
- Accomplished several actions consistent with strategy: market information, heavy partnering, affected many markets
- The idea to privatize labs was not opposed by this team

Foreign Team

- The foreign role was not natural for any of the players, but they quickly determined that they could do an adequate job of role playing
- Team developed characteristics of more developed (as opposed to developing) countries
- Primary interest was in US policy and how it would have positive impact on their countries
- Successful in getting partners for their initiatives

Investment Priorities

The game emphasized the importance of the labs current missions in national security, energy and environment. However, there was broad support for natural extensions of the labs capabilities into other areas of national importance. These included technologies for education, biomedicine, information surety, the criminal justice system, mine detection and removal, science-based regulations, and clean water initiatives. A great deal of partnering was evident, both for the Toolkit and for new investment options.

Technologies

The priorities of Toolkit technology investments as measured by the ratio of the investment to the 50% investment point (and secondarily on total amount invested) are listed below (for investments that equaled or exceeded the 50% probability, regardless of success or failure). The number of partners is shown in parentheses.

- (7) Joint labs-university program for development and deployment of new technologies to reduce costs and increase quality in US schools (K-12) and colleges.
- (2) Creation of a virtual replacement for the Office of Technology Assessment, managed by the labs and pulling resources from universities, labs and industry to respond quickly to Congressional questions.
- (7) High-performance computing.
- (5) Joint industry-labs-university program to develop efficient and clean fuels.
- (2) Science-based regulations
- (5) Joint industry-labs-university program to develop software for medical diagnosis, epidemiological studies, etc.
- (5) Industry becomes a partner in ASCI.

Two technologies received investments only from the industry team (no partners) and the investments were too small to succeed:

- Program to ensure the integrity and security of telecommunications.
- Industrial ecology program. (However, later in the game the industry team brought in three additional partners and reinvested in this technology successfully.)

Only nine of the 26 technology options (35%) received a positive investment, indicating that the teams were carefully selecting among the technologies they wished to pursue, and there was a commonality in many objectives among the teams/stakeholders.

After the Toolkit investment period, the teams produced many new investments. Almost all of these involved investments far in excess of the 50% point. Listed below are those options that attracted investments sufficient to generate a base success probability equal to or greater than 90%.

- (3) Evaluation of all environmental regs for risks vs costs, and science-based. (This built further on science-based regulations above, indicating a high priority.)

- (4) Joint industry-government effort on industrial ecology.
- (2) University-industry partnership for entrepreneurial development utilizing information services.
- (2) CRADA for improved product reliability using diagnostics and predictive modeling. Stockpile related.
- (3) Labs develop surety and integrity for images on WWW. Dual use: proprietary, security, defense readiness.
- (2) Science and technology based education program to increase number of high school students going to college by 5%.
- (4) University research on DNA technologies to increase food production in foreign countries.

Other investments that garnered at least $400M and investment success probabilities of 69% or more were:

- (2) Build a facility to manufacture criminal justice and health care devices. (A result of developing those technologies in earlier investments.)
- (4) Upgrade mine detection and inactivation to include plastics and explosives in luggage. (A previous investment developed an initial capability for detecting metallic mines.)
- (5) (second investment, since the original Toolkit investment failed, indicating a very high priority): Develop alternative efficient and clean fuels.
- (8) Global clean water initiative.
- (5) Develop a working fusion device, but not to commercialization.

Many other large investments were made in curing AIDS, telemedicine, virtual lab concepts, and biomedical technologies.

Policies

Fifteen of the 39 (38%) policy options received some positive investment, indicating a selectivity and commonality very similar to the technology investments. Ranked as above (first by ratio, second by total investment) the most desired policy options with investment ratios of 50% or better were:

- (6) Make R&D tax credit permanent.
- (4) Congress adds internal security and safety (improving the criminal justice system) as a new mission for the labs.
- (1) The National Tech Transfer act was amended to allow labs to give intellectual property rights to foreign entities. (Only the Foreign team invested in this; no other team blocked it with negative votes, possibly because they were unaware of it.)
- (5) Repeal the Glass-Steagall act.
- (3) Foreign companies create a US-managed venture capital firm. (Investments from Foreign team, Weapons Labs and Universities.)
- (6) Congress increases non-defense R&D spending by 5%.
- (3) Congress reforms the product liability system.
- (1) A new multi-stage standards setting program is created.
- (2) The Bayh-Dole act is amended to remove giving automatic title to intellectual property to university, not-for-profit, and small-business partners.
- (2) Several labs are privatized.

After the Toolkit period ended, the teams struggled to decide which labs to privatize. This led to significant unhappiness with Congress and an election in which the entire Congressional incumbent team was replaced.

An important late policy development was that Congress passed legislation to remove all impediments to deployment of advanced information and telemedicine systems across state boundaries by establishing a national system for medical licensing.

DOE players (actually played by DOE/ALO, and not lab people) felt that they got involved in areas that are not currently part of DOE's mission, but that were important to the nation. They also felt that it was difficult for the different agencies (e.g., DOE and DOD) to partner under current conditions.

If there were a single message from the game, it would be to use the nations R&D resources to solve pressing national problems. Restrictions to specific missions may not be wise. However, there was a recognition that balancing the budget is also important.

Player Evaluations

In order to assess how well the game objectives were met, and how effectively the game was conducted, players were polled both at the beginning and end of the game. Polling was done anonymously using electronic keypads that transmit signals using radio frequency. Questions were asked in three different areas: 1) thoughts about R&D, 2) rating the game performance of each team, and 3) general game objectives. Team demographics were also collected electronically so that we could distinguish differences between teams on each question.

Thoughts About R&D

The players were all polled for their feelings about R&D both at the beginning and the end of the game. The first four questions were based on the importance of R&D and used a voting scale of *1=very little* to *3=neutral* to *5=very much*. The next set of three questions dealt with tradeoffs between federal funding for R&D and federal funding for other programs, with voting on a scale of *1=greatly reduce R&D* to *3=keep the same* to *5=greatly increase R&D*. The last question in this section asked the players to estimate the time lag between discovery and major application, with voting on a scale of *1=0-5 years*, *2=5-10 years*, *3=10-20 years*, *4=20-30 years*, and *5=>30 years*.

Table K-1. Average responses for Thoughts about R&D.

Question	Begin	End
1. How important is R&D to the economy?	4.62	4.52
2. How important is R&D to the future quality of your life?	4.45	4.41
3. How important are the national labs to the national R&D delivery system?	3.66	3.70
4. Technology transfer resembles corporate welfare.	2.51	2.44
5. In tradeoffs between federal funding for R&D and social programs, we should:	3.64	3.59
6. In tradeoffs between federal funding for R&D and defense programs, we should:	3.46	3.53
7. In tradeoffs between federal funding for R&D and the federal deficit, we should:	3.37	3.16
8. What do you think is the time lag between discovery/innovation and major application?	2.96	2.84

Table K-1 contains all of the questions regarding thoughts about R&D with their average responses, and shows that there was no significant shift in opinion from the beginning to the end of the game, when all players are viewed as a whole. The players felt that R&D was very important to both the economy and quality of life. They felt less strongly that the national labs were important contributors to the national R&D delivery system, but felt that the labs are important. With regard to technology transfer resembling corporate welfare, the players were slightly on the side of 'not corporate welfare.' When considering federal funding priorities, players slightly favored increasing R&D spending over both social and non-R&D defense programs, but were neutral with respect to the deficit. On average, the players felt that the time lag between discovery and application was 15 years.

Although Table K-1 shows no significant changes in attitude as a result of the game, a more detailed examina - tion of the data suggests that the game had a significant impact on some of the players. Figure K-1 shows changes in average responses on a team-by-team basis for four of the questions in Table K-1. Of note are the responses to the statement that technology transfer resembles corporate welfare. Five of the ten teams had an average response that changed by more than 1.0 (on a scale of 1 to 5). The public, Congress, and industry/companies teams all felt very strongly by the end of the game that tech transfer did not resemble corporate welfare, where at the beginning they had the opposite opinion. By contrast, the OFA (federal agencies) and foreign teams both felt much more strongly at the end of the game that tech transfer was corporate welfare than they did at the beginning of the game.

When Figure K-1 is examined by teams, it shows that the OFA and foreign teams responses were impacted by the game more than were the other teams. Both the OFA and foreign teams responses show differences greater than 1.0 for three of the four questions in Figure K-1. By the end of the game, the OFA team felt that the national labs were not important in national R&D, and that addressing the deficit was more important than increasing R&D, both switches from their earlier opinions. The foreign team felt likewise with regard to the deficit, and felt more strongly that R&D should take priority over non-R&D defense spending. The

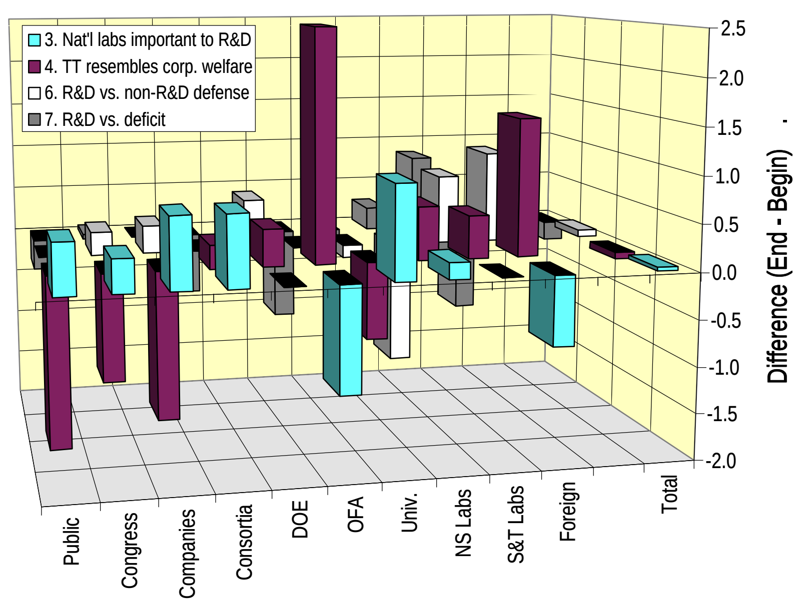

Figure K-1. Impact of game on 'Thoughts about R&D' on a team-by-team basis.

reasons for these changes in attitude are not specifically known, although it is clear that the game played a role in the changes. Note that generalizations about the attitudes of the different stakeholders cannot be made from these data, since the majority of players in this prototype game were Sandia staff.

Team Performance

Each player was asked to rate each team directly after the final presentation made by that team (on a scale of 1-5, 5 being the highest rating). Table K-2 shows the ratings of all teams in three categories: rating by all players, self-rating, and their rating of all other teams. A most notable result is that seven of the ten teams rated their performance as better than that of every other team, and two of the remaining three teams rated themselves the second highest performers. Only the Congress team was realistic, rating themselves in the middle of the pack. For the seven teams that rated themselves highest, the average difference between their self-rating and their rating of all other teams was 0.97.

Table K-2. Ratings of team performance.

Team	Average Ratings		
	by All	by Self	of Others
Public	3.78	4.67	3.37
Congress	3.16	3.40	3.37
Companies	3.44	5.00	3.76
Consortia	3.72	3.75	3.31
DOE	3.82	4.50	3.71
OFA	3.60	4.25	3.19
Universities	3.34	4.00	3.59
NS Labs	3.66	4.20	3.68
ER/EM Labs	3.50	4.67	3.52
Foreign	3.96	4.50	3.77

The team that was rated the highest by all players in the game was the foreign team, followed closely by the DOE and public teams. Congress received the lowest rating, consistent with their self-assessment. The OFA team was the stingiest with its ratings, rating all other teams with an average of 3.19, and themselves much higher.

The results also revealed some mutual dislikes among teams. The OFA and public teams each rated the other's performance lowest, while the universities and Congress each gave the other their lowest ratings.

Generic Objectives

An overview of polling results on the generic objectives of this prototype game is given in the main body of the report, along with similar results from the real Future@Labs.Prosperity Game (see page 50). A measure of the attitude each team had toward the game in general can be shown by the average response given to all 16 questions dealing with the generic objectives. Table K-3 shows that the public and industry/companies teams were most satisfied with the game, while the labs and foreign teams were least satisfied.

Table K-3. Average response by teams regarding generic objectives.

Team	Overall average
Public	4.28
Congress	3.87
Companies	4.33
Consortia	3.53
DOE	3.92
OFA	3.50
Universities	3.59
NS Labs	3.03
ER/EM Labs	3.21
Foreign	2.71

Significant Changes Made as a Result of the Prototype

Several changes were made in the real game based on feedback from both players and staff in the prototype. The most significant of these are listed here.

- The Public and Consortia teams were dropped from the game, and three more Industry teams were added. The purpose here was to cover more industry segments and keep teams from representing just one company
- The time allotted for session 1 was increased to allow for more complete strategy building
- Session 2 was modified to focus exclusively on the Toolkit; no money for other purposes was allocated in this session
- The agreement process was refined to provide smoother flow, greater traceability, and less backup at the Control team
- Money in sessions 3-5 was distributed directly to each team based on the full funding 'food chain' rather than having primary money teams pass their allocations down. This was meant to keep play focused on the vision and strategy rather than getting stuck on dollars
- Metrics updates were based on staff voting during the prototype game. This was changed in the real game such that the metrics depended upon the game play and investment strategies of the teams

Appendix L: Glossary

ADaPT Advanced Design and Production Technologies
AMPEC Advanced Materials and Processes for Economic Competitiveness
ANL Argonne National Laboratory
ASCI Accelerated Strategic Computing Initiative
ASKC Allied Signal Kansas City
BNL Brookhaven National Laboratory
CPI Consumer Price Index
CRADA Cooperative Research and Development Agreement
DOC Department of Commerce
DOD Department of Defense
DOE Department of Energy
DOT Department of Transportation
EPA Environmental Protection Agency
FAA Federal Aviation Administration
FDA US Food and Drug Administration
FFRDC Federally Funded Research and Development Center
FLC Federal Laboratory Consortium for Technology Transfer, organized in 1974 and formally chartered by the Federal Technology Transfer Act of 1986 to promote and strengthen technology transfer. Includes more than 600 federal laboratories and their parent departments and agencies.
FLOPS Floating point operations per second; a measure of computing speed
GAO Government Accounting Office
GDP Gross Domestic Product
GOCO Government Owned Contractor Operated
GOGO Government Owned Government Operated
HHS Health and Human Services
HPC High Performance Computing
Industrial Ecology: The application of ecological principles to industrial processes. Its objective is to continually increase the resource-efficiency of those processes – in other words, to increase their knowledge-content.
INEL Idaho National Engineering Laboratory
ITER International Thermonuclear Experimental Reactor: An international (Europe, Russia, Japan, US) program to build a fusion reactor; The Engineering Design Activities (EDA) is a 6-year program that began in July 1992. ITER costs have been estimated at $8B, but some think it will cost twice that.
LANL Los Alamos National Laboratory
LBNL Lawrence Berkeley National Laboratory
LLNL Lawrence Livermore National Laboratory
MCC Microelectronics and Computer Corporation
MEMS Microelectromechanical systems that merge information processing and communication with sensing and actuation. The worldwide market for MEMS devices for three key defense categories - miniaturized inertial measurements, distributed sensing, and information technology - is expected to increase to $14B per year by 2000.
micro- one millionth-
MIT Massachusetts Institute of Technology
MITI Ministry of International Trade and Industry (Japan)
nano- one billionth-
NASA National Aeronautics and Space Administration
National Security: Protection of American citizens from threats to their safety, security, prosperity, and well-being.
NIF National Ignition Facility; a massive laser fusion laboratory that would determine the safety and reliability of the US nuclear weapons stockpile in the absence of testing.
NIH National Institutes of Health
NIST National Institute of Standards and Technology
NREL National Renewable Energy Laboratory
NSF National Science Foundation
OMB Office of Management and Budget
ORNL Oak Ridge National Laboratory
OTA Office of Technology Assessment
PNL Pacific Northwest Laboratory
R&D Research and Development
ROI Return on Investment
SBA Small Business Administration
SBIR Small Business Innovative Resource
SNL Sandia National Laboratories
SRC Semiconductor Research Corporation
S&T Science and Technology
STTR Small Business Technology Transfer
STS Science, Technology and Society
TEAM Technologies Enabling Agile Manufacturing
Technology Roadmap: A strategic plan that collaboratively identifies product and process performance targets and obstacles, technology alternatives and milestones, and a common technology path for R&D activities."
Tera Trillion; 10^{12}
TFLOPS Trillion floating point operations per second; a measure of computing speed. Also, a $45.5M project under ASCI, whose goal is to produce a massively parallel computer capable of 1.8 TFLOPS.

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